

ON THE BRITISH SPECIES OF SIMULIUM.—II. THE EARLY STAGES ;
WITH CORRECTIONS AND ADDITIONS TO PART I.

BY F. W. EDWARDS.

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In the introduction to the first part of this paper* it was remarked that very little exact work had been published on the adult European SIMULIIDAE. This is equally true of the larvae and pupae ; in fact no one has attempted to describe the early stages of more than two or three of the common species. Moreover, in spite of their great interest, and the ease with which they can be collected and reared, they have apparently been almost entirely ignored by collectors, so that whereas in publishing my previous work I was able to acknowledge valuable assistance from a number of fellow entomologists, the results given in the following pages are, unless otherwise stated, due to my own observations. I wish especially to thank Mr. M. E. Mosely for the early stages of *S. subornatum*, the last species to come under my notice in the pupal stage. While there are still many important gaps in our knowledge which remain to be filled, it has been thought worth while to state without further delay the results that have been obtained so far.

The purpose of the present paper is to give the writer's observations on the biology of the insects, and to characterise, sufficiently for purposes of identification, the known larvae and pupae. In the course of rearing some species from the pupae, it was discovered that the females of the *latipes* group had been associated previously with the wrong males, and their characters had been badly confused, both in my original paper and in the reprint of it which appeared in the Entomologists' Monthly Magazine. Owing to this somewhat serious error, which has led the writer to adopt a different interpretation of Fries' *S. aureum*, and owing also to the discovery of four apparently new species, it has been thought advisable to tabulate afresh the adults of both sexes. I am indebted to Mons. E. Séigny, of the Paris Museum, for examining at my request Meigen's types of *Simulium* ; he reports that in *ornatum*, *replans*, *argyreatum*, *sericatum* and *latipes* of Meigen, the types agree with the interpretation here given.

From the systematists' point of view the most valuable memoirs which have appeared dealing with the early stages of *Simulium* are those of Lutz†, Malloch‡ and Pomeroy§ on the American species. To all these writers the present author is glad to express his indebtedness. As regards the early stages of the SIMULIIDAE outside Britain and North and South America, they are still scarcely known, though Mr. Pomeroy has lately undertaken the study of the African species.||

* Bull. Ent. Res., vi, pp. 23-42 (1915).

† LUTZ, A., Mem. Inst. Oswaldo Cruz, i, p. 124 (1909), and ii, p. 213 (1910).

‡ MALLOCH, J. R. "American Black Flies or Buffalo Gnats."—U.S. Dept. Agric. Bur. of Ent. Tech. Series 26, 1914.

§ POMEROY, A. W. J. "Notes on five North American Buffalo Gnats of the genus *Simulium*."—U.S. Dept. Agric. Bull. 329, 1916.

|| While this work has been passing through the press a valuable paper on the German species has been published by Dr. K. FRIEDRICHS (Vorläuf. Mitt. Sitzb. Abh. Naturf. Ges. Rostock, vii, pp. 211-226, Oct. 1920). The adults, pupae and habitats of nine species are briefly described).

Before passing to tabulate the species and consider them individually there are a few points which seem to be of sufficient general interest to claim attention here.

Method of Rearing and of Association of Larvae and Pupae with Adults.—It was pointed out by Newstead* that the pupae of *Simulium* when removed from the water and placed in a moderately damp atmosphere without superfluous moisture will readily complete their transformation into adults. This method of rearing has proved invaluable, and provided the vessel in which the pupae are kept is not too small, and is kept slightly moist, it practically never fails: thousands of specimens have been reared in this way. If however a male pupa which it is desired to rear should die, it can easily be identified by dissecting out the genitalia.

In a colony of larvae where even a moderate proportion are full-grown, some are sure to be found which exhibit a round black spot on each side of the prothorax, conspicuous even to the naked eye. This is the respiratory organ of the developing pupa showing through the larval skin, its component filaments being coiled up into a small space. The filaments can be very easily dissected out with a pair of needles, and a positive identification of larva and pupa obtained. If in the same colony there are also blackish, well-developed pupae, the species can be identified by dissecting these without the necessity of waiting for specimens to hatch out. It is very desirable to identify larvae by this reliable method, since one very frequently finds several species living together in the same colony; though in a small area of a few square inches one will usually greatly outnumber the others.

Over-wintering.—Some species, notably *S. ornatum*, appear to continue breeding throughout the winter, even in the coldest weather, though, as might be expected, the rate of development is greatly retarded. Of such species there must be at least three broods in the year. Others, such as *S. latipes*, pass the winter as young larvae, developing rapidly in the early spring; probably these are normally single-brooded. The species which appear in such vast numbers in spring in our muddy-bottomed rivers may possibly winter in the mud in the egg stage, but I have not been able to obtain any positive evidence of this. Another possibility, and perhaps a more likely one, is that the females may hibernate, but I have never found them in a torpid state. However, as Mr. Hamm has pointed out to me, the specimens of *S. equinum* and *S. argyreatum* captured very early in the year are generally, if not always females. More observations are needed on this point.

Oviposition.—Very little is yet known as to the egg-laying habits of the different species, but it would seem that great variation exists. I have been able to confirm the very interesting observations of Mr. H. Britten† on *S. equinum*, and have added some further particulars below. I have also found and hatched the eggs of *S. aureum*, which, unlike those of *S. equinum*, are hard-shelled and not enclosed in a mass of jelly; the newly-hatched larva of this species also has a much more strongly-developed egg-burster, so that it would seem that this species may be adapted to resist desiccation in the egg state.

Habitat of Larvae.—The larvae which I have met with may be classified according to their habitat into (1) those which live on water-plants (or other objects if available)

* Ann. Trop. Med., i, p. 40.

† Ent. Mo. Mag. (3), i, 1915, p. 150.

in sluggish and permanent rivers such as those of East Anglia ; (2) those which live on rocks, stones (chiefly the upper sides) and sometimes on water-plants in swift mountain streams, which may become dry in dry seasons ; and (3) those which live chiefly on the undersides of stones, in small temporary streams, which are dry for several months of the year. These classes are not rigidly defined, either in regard to the water-courses or to the insects, but it is often possible to say from the appearance of a stream what species will be found in it. Some, for example *S. latipes*, are more particular in their choice of a locality than others, such as *S. ornatum*, which is perhaps the most catholic in its tastes. The different species found in one type of stream are not all closely related, as is shown by a study of the adults and pupae ; but it is a noteworthy fact that most of the larvae which live in very rapid streams have their anal gills very much branched, while most of those which live in sluggish rivers have the three main branches simple. It might have been supposed that the more rapidly-moving and presumably more highly aerated water would not need such a large surface in the gills for the insects to accomplish their respiration, but this is not what we actually find. It may be that the presence of water-plants assists respiration to an even greater extent than movement of the water.

Larvae always occur in the greatest numbers in the swiftest part of whatever stream they are in. The slow-river species furthermore show a decided preference for those water-plants (e.g., *Scirpus*, *Sparganium* and *Ranunculus*) which have long and narrow or much divided leaves, the reason perhaps being that such leaves are waved about by the current and thus provide better aeration ; the larvae occur most abundantly towards the tips of the leaves.

The species found on stones all show a decided preference for clean stones ; when there is much moss or algal growth or accumulation of sediment on the stones *Simulium* larvae are not often found in numbers. This may perhaps be due to the growth affording shelter for predaceous insect enemies. It is also very noticeable that *Simulium* larvae are never very abundant in those stony streams where there are large numbers of a certain small caddis-worm which lives in pebbly cases attached to the stones.

Larval Moults and Growth Changes.—I have been able to follow the entire larval development in only one species, *S. latipes*, but it will probably be safe to regard this as typical of all in respect to the number of moults and the principal developments which take place in the larval stage. In this species there are six moults, the change to the pupa taking place at the sixth. The first-stage larva is readily distinguishable from the others by the presence of the egg-burster, a small chitinous tooth near the posterior end of the clypeus, it being much more strongly developed* in *S. latipes* and *S. aureum* than in *S. venustum* (?) ; in the former it is plainly visible under a $\frac{2}{3}$ " objective as a dark spot in the middle of the back of the head ; in the latter it is only discernible with a higher power. The first-stage larva is also characterised by one or two pairs of small hairs on each side of the egg-burster, which disappear after the first moult ; by the smaller number of elements in the mouth-brushes and in the

* The actual tooth is no larger, but is darker in colour and surrounded by a darker and more strongly chitinised area of the general integument of the head. In this respect *Simulium* differs strikingly from the CULICIDAE, in which the egg-burster is surrounded by a membranous area.

anal sucker—in *S. latipes* about 15 mouth-brush hairs and about 4 teeth in each sucker-row ; and by the apparently two-jointed antennae, the second joint being the minute cone-shaped one. The later stages differ from one another chiefly in the size of the head, and in the progressively greater number of hairs in the mouth-brush and teeth in the sucker-rows. The full-grown larva of *S. latipes* has about 40 hairs in the mouth-brush and 12–15 teeth in the sucker-rows. The anal gills in this species are quite simple in the first three larval stages, very slightly branched in the fourth, and distinctly so in the last. In this species, as in several others, the head is much darker in colour in the younger larvae, and the markings are less distinct.

Diagnostic Characters of Larvae and Pupae.—It is not the writer's intention to describe the early stages in any detail, but merely to indicate the main points of difference between them. In the larvae these are to be found chiefly in the number of joints in the antennae, in the form of the anal gills, in the markings of the head, and to some extent in the colour of the body. The structure of the mentum and the number of hooks in the anal sucker also vary much with the different species, and some use has had to be made of these points. The mandibles and maxillae certainly exhibit good specific characters, but these have been ignored, as the more obvious distinctions are sufficient to separate all the British species. In the pupae the only characters of systematic value are the form of the cocoon and of the prothoracic respiratory filaments, but these are often so well-defined that they form a much easier means of identifying the insect than any characters of the adult ; they have the advantage of being entirely uninfluenced by sex, and are subject to very little variation.

Seasonal Variation.—The occurrence of definite seasonal variation in the Diptera is only known in a very few instances. The only two cases, so far as I am aware, in which it is regarded as proved, have been recorded by Hensel* for *Dryomyza flaveola*, and by Aldrich† for *Cerodonta dorsalis*. It has also been suggested by Verrall that *Tipula oleracea* and *T. paludosa* may be summer and autumn forms of the same species, but this is not definitely established.

In the case of *Simulium* the spring brood of *S. equinum* is conspicuously larger than the subsequent broods, while there may also be a slight difference in *S. ornatum* ; but this latter is such a variable species that it is difficult to say for certain. In *S. argyreatum*, however, we have a well-marked case of seasonal variation, as both males and females of the spring brood are fairly readily distinguishable by colour and markings, as well as by their larger size, from the later broods ; the spring form is described below as var. *sericatum*, Mg. For absolute proof that these two forms are really the same species it would of course be necessary to breed one from the other, which I have not been able to do, but still I think the assumption may be justified for the following reasons :—(1) the male genitalia are peculiar and are identical in structure in the two forms, which are also alike in all other structural characters ; (2) in any locality where one form occurs the other may also be found ; (3) the spring form is never found after about the middle of May, and the summer form never before the beginning of that month.

* Berl. Ent. Zeit., 1870, p. 133.

† Ann. Ent. Soc. Amer., xi, 1918, p. 63.

Blood-sucking Habits.—In my previous contribution I stated that some of our commonest species were probably not bloodsuckers, but this opinion has since proved to be quite erroneous, as I have had abundant evidence that both *S. ornatum* and *S. latipes* will attack man ; and though there are still species (such as *S. aureum*) against which there is no evidence, it will probably be safe to assume that all the species may on occasion develop this habit. It would seem that their blood-sucking propensity depends much more on the weather than on the particular species ; a still, warm and sunny afternoon in April or May, and perhaps to a somewhat less extent later in the year, will always rouse them to activity. Some further details on this subject are given in the sequel.

Range of Flight.—It has often been observed that *Simulium* may be found at considerable distances from their breeding places, and though this may in part be due to some stream having dried up and so been overlooked by the observer, yet it is certain that these insects can fly long distances. I have frequently taken *S. ornatum* and other species at a distance of a mile from the nearest possible breeding place, while on one occasion I took *S. venustum* on Birds Hill, near Clothall, Herts., two miles from its home in the river Ivel. This power of flight is not by any means confined to females in search of food, as most of my records of specimens taken far from their breeding haunts are of small swarms of males.

Parasites and Associates.—E. H. Strickland* has described in detail three parasites of *Simulium* larvae in North America : a worm of the genus *Mermis*, the sporozoans *Glugea* spp., and an undetermined Gregarine. I have found what appear to be these same parasites in various species in this country, though the parasitised specimens are never in very large numbers, *Mermis* in particular being rarely met with. As observed by Strickland, parasitised individuals are generally much above the average size.

It may also be of interest to note that small Chironomid larvae are frequently found within the cocoons, particularly of *S. ornatum*. I believe these are the larvae of a small species of *Orthocladius*, the cocoons of which are often to be seen lying close against the side of a *Simulium* cocoon. Whether the Chironomid is dependent upon the *Simulium* or whether it also occurs away from them I have not been able to ascertain.

Simulium as Food for Fish.—From the immense numbers in which larvae and pupae of *Simulium* occur in many rivers, it might be imagined that they would form an important part of the diet of fish, but in the case of trout at least this does not seem to be so. I have examined the stomach-contents of a number of trout obtained by Mr. M. E. Mosely, and found very few *Simulium* larvae or pupae among them. In so far as the genus was represented at all, it was mostly by adults (chiefly males) of *S. ornatum* and *S. equinum*. Mr. Mosely suggests that this would be accounted for by the habits of the trout, which feeds mostly at the surface or by suction from the bottom. The adult flies found would be those which had fallen into the water ; among these, males from dancing swarms would no doubt be in excess. As noted below under *S. tredecimatum*, one case has been observed in which large numbers of *Simulium* larvae were found in the stomach of a trout.

* Jl. Morph., Philadelphia, xxiv, 1913, pp. 43–105.

*Control Measures.**—As has been pointed out by several previous writers, the best method for reducing the numbers of *Simulium* is the cutting and removal of weeds in rivers and streams; to be effective this should be done in March. This method would not affect those species which live chiefly on stones, such as *S. reptans*, *S. tuberosum* and *S. latipes*. Probably all that could be done to check these species would be the removal of the most heavily infested stones; the densest colonies could easily be discovered, as they are usually to be found mainly at certain favourable spots.

TABULATION OF SPECIES.

Adult Males.

- | | | |
|----|--|----------------------------|
| 1. | Front metatarsi more or less flattened in a vertical plane; front tibiae, and usually also the thorax and abdomen, with silvery markings; claspers flattened dorso-ventrally (Group A) | 2. |
| | Front metatarsi cylindrical; front tibiae, thorax and abdomen without silvery markings, though the tibiae may have silvery pubescence; claspers not flattened (Group B) | 11. |
| 2. | Hind metatarsi distinctly thickened in a vertical plane; pubescence of thorax somewhat coarser; claspers three times as long as broad | 3. |
| | Hind metatarsi slender, nearly cylindrical; pubescence of thorax very fine; claspers hardly longer than broad | 10. |
| 3. | Hind tibiae on basal $\frac{1}{3}$, metatarsi on basal $\frac{1}{2}$, conspicuously pale | 4. |
| | Hind tibiae and metatarsi all black, or nearly so | 6. |
| 4. | Membranous area of pleura with soft hairs; front metatarsi 5 times as long as broad | <i>ornatum</i> , Mg. |
| | Membranous area of pleura quite bare (even when freshly emerged); front metatarsi about $6\frac{1}{2}$ times as long as broad | 5. |
| 5. | Clasper rather slender, external margin slightly concave, the spine terminal | <i>variegatum</i> , Mg. |
| | Clasper broader, external margin strongly convex in the middle, the spine subterminal | <i>monticola</i> , Fried. |
| 6. | Middle tibiae conspicuously yellowish at base | 7. |
| | Middle tibiae all black | 8. |
| 7. | Front metatarsi about $5\frac{1}{2}$ times as long as broad; silvery markings of thorax inconspicuous; stylus of adminiculum hairy | <i>subornatum</i> , sp. n. |
| | Front metatarsi about 4 times as long as broad; two conspicuous rounded silvery spots on thorax; stylus of adminiculum bare | <i>reptans</i> , L. |
| 8. | Front tibiae conspicuously silvery in front | 9. |
| | Silvering of front tibiae much less conspicuous; clasper rather slender on apical half, with a dorsally-projecting thumb-like process near the base | <i>tuberosum</i> , Ldst. |

* These are well summarised by Wilhelmi in a recent German Government publication (*Die Kriebelmückenplage; Uebersicht über die Simuliidenkunde, besonders in practischen Hinsicht.* Jena, Oct. 1920).

9. Clasper shaped much as in *tuberosum*, but somewhat broader, and thumb-like process shorter; adminiculum differing from *tuberosum* and resembling the following *venustum*, Say (= *austeni*, Edw.).
Clasper much broader, without sub-basal thumb-like process and without articulated spine *morsitans*, Edw.
10. A pair of lateral, almost triangular, silvery markings on front of mesonotum *argyreatum* (Mg.) Ldst.
These markings greyish, not silvery and continued backwards as two narrow lines to the hind margin of the mesonotum *argyreatum* var. *sericatum*, Mg.
11. Venation normal; second joint of hind tarsi more or less excavated above near the base; legs not densely hairy 12.
Venation abnormal, an extra vein (R_{2+3}) present; second joint of hind tarsi cylindrical; legs with long and rather dense hair *hirtipes*, Fries.
12. Hind metatarsi almost cylindrical, and conspicuously pale towards the base; membranous area of pleura with soft hairs *equinum* (L.) Edw.
Hind metatarsi more or less thickened vertically; entirely dark in colour; membranous area of pleura quite bare 13.
13. Pubescence of thorax golden; second hind tarsal joint deeply excavated .. 14.
Pubescence of thorax dull whitish yellow; second hind tarsal joint only slightly excavated *subexcisum*, Edw.
14. Hind metatarsi barely three times as long as broad *latipes*, Mg.
Hind metatarsi quite four times as long as broad 15.
15. Clasper nearly cylindrical, of even width throughout *angustitarsis*, Ldst.
Clasper much swollen towards the base, and rather short *aureum*, Fries. (= *bracteatum*, Coq.; = *angustipes*, Edw.).

Adult Females.

1. Front metatarsi flattened in a vertical plane; front tibiae, and sometimes the thorax, with silvery markings; last three abdominal tergites shining (Group A) 2.
Front metatarsi cylindrical; front tibiae and thorax without silvery markings, though the former may have silvery pubescence; last three abdominal tergites dull (Group B) 12.
2. Frons (above antennae) and face (below antennae) grey, dull 3.
Frons blackish, shining (face usually grey) 5.
3. Claws with a small sharp tooth just before the middle 4.
Claws not toothed; coloration like *ornatum*; membranous area of pleura bare *subornatum*, sp. n.
4. Femora mainly dark; membranous area of pleura with soft hairs; front metatarsi 5×1 *ornatum*, Mg.
Front and middle femora almost all yellow; membranous area of pleura bare; front metatarsi 6.5×1 *variegatum*, Mg.

- 5. Claws toothed ; thoracic markings as in *ornatum* 6.
- Claws simple ; thoracic markings different, or absent 7.
- 6. Membranous area of pleura with soft hairs .. *ornatum* var. *nitidifrons*, n.
- Membranous area of pleura bare *monticola*, Fried.
- 7. Face black, shining, like the frons ; legs mainly black .. *tuberosum*, Ldst.
- Face grey ; legs more extensively pale 8.
- 8. Thorax almost dull, with coarser pubescence 9.
- Thorax somewhat shining, with much finer pubescence 11.
- 9. Basal two-thirds of hind tibiae clear yellow *reptans*, L.
- Basal half of hind tibiae yellow, but less sharply distinguished from the black apical portion 10.

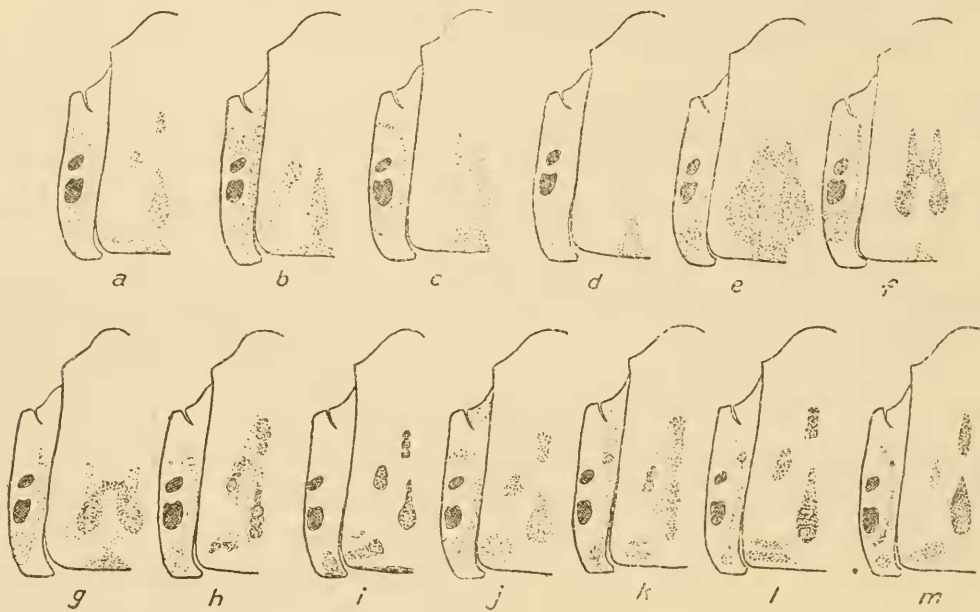


Fig. 1. Head markings of *Simulium* larvæ (the markings vary a good deal in intensity in most species ; individuals have in each case been chosen which showed the markings most strongly developed. The figures are somewhat diagrammatic and not strictly to scale) : a, *S. ornatum* ; b, *S. variegatum* and *S. monticola* ; c, *S. subornatum* ; d, *S. reptans* ; e, *S. reptans* var. *galeratum* ; f, *S. morsitans* ; g, *S. venustum* ; h, *S. argyreatum* ; i, *S. equinum* ; j, *S. latipes* ; k, *S. aureum* ; l, *S. angustitarsis* ; m, *S. subexcisum*.

- 10. Rather less than basal half of mid tibiae yellowish .. *venustum*, Say (= *austeni*, Edw.).
- Rather more than half of mid tibiae yellowish *morsitans*, Edw.
- 11. Thorax brightly shining ; front coxae reddish .. *argyreatum* (Mg.) Ldst.
- Thorax less shining, with traces of the two greyish longitudinal stripes seen in the male ; front coxae blackish .. *argyreatum* var. *sericatum*, Mg.
- 12. Vein R_{2+3} absent (normal) ; second joint of hind tarsi more or less excavated above near the base 13.
- Vein R_{2+3} present ; second joint of hind tarsi cylindrical ; claws simple and rather small *hirtipes*, Fries.

13. Claws simple and very large ; thorax with three narrow black lines (hidden in good specimens by golden pubescence) *equinum* (L.) Edw.
Claws smaller and with a large basal thumb-like projection ; thorax unstriped 14.
14. Pubescence of thorax golden or brassy ; second hind tarsal joint deeply excavated 15.
Pubescence of thorax and abdomen dull yellowish-white ; second hind tarsal joint only slightly excavated 17.
15. Pubescence of abdomen very scanty, hairlike and whitish ; abdomen pink in life ; legs nearly all black *latipes*, Mg.
Pubescence of abdomen dense, scale-like and golden ; abdomen yellowish in life 16.
16. Femora and tibiae clear yellow with black tips *aureum*, Fries.
Femora and tibiae darker, the latter with a dark ring close to the base *angustitarsis*, Ldst.
17. Pubescence of thorax all pale *subexcisum*, Edw.
Pubescence of thorax with three dark stripes, the middle one divided by a line of pale hair-like scales *yerburyi*, sp. n.

Full-grown Larvae.

1. Antennae 4, 5, or 6 jointed, though the division between the first two, three or four is somewhat obscure 2.
Antennae 3 or 9 jointed 16.
2. Last abdominal segment rounded ventrally, or with only very small papillae ; antennae usually 5 jointed 3.
Last abdominal segment with a pair of large conical papillae ; antennae 4-jointed, but very long and slender 14.
3. The three anal gills simple (sometimes with a few short branches in *galeratum*) 4. Anal gills each with 5–10 branches* (4 or 5 in *reptans*) 9.
4. Anal sucker with 100 or more rows of hooks, 18–25 hooks in each row .. 5.
Anal sucker with 65–80 rows of hooks, 12–18 hooks in each row ; body not bright green ; dark “eyebrows” present 6.
5. Central and lateral teeth of mentum enlarged ; head markings distinct, but dark eyebrow absent ; body bright green *equinum*, L.
All teeth of mentum small ; head markings very indistinct, but a dark eyebrow present ; body colour uncertain *tredecimatum*, sp. n.
6. Abdomen without distinct banding ; skin round anus with numerous minute trifid spines 7.
Abdomen with a distinct dark band on each segment dorsally ; skin round anus nearly bare 8.

* When the gills are branched they are much less frequently retracted than when they are simple. The gills of *S. subornatum* have not been observed ; since they were retracted in all the specimens examined, they are probably simple.

7. Head markings as in fig. 1a ; anal spines very numerous and dark
ornatum, Mg.
 Head markings as in fig. 1c ; anal spines less numerous .. *subornatum*, sp. n.
8. Back of head with a large roundish black area .. *reptans*, var. *galeratum*, n.
 Back of head with four elongate dark spots, usually enclosed in a suffused brownish area *argyreatum*, Mg.
9. Larger species ; gills with 8-10 branches ; abdominal banding inconspicuous or absent ; dark "eyebrow" usually conspicuous ; clypeal markings of the *ornatum* type though often indistinct (cf. also *subornatum*, with different head marking) 10.

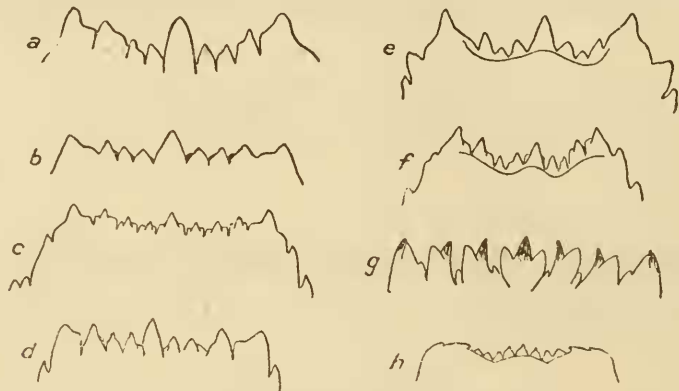


Fig. 2. Apex of mentum of *Simulium* larvae ; all $\times 150$. a, *S. ornatum* ; b, *S. subornatum* ; c, *S. reptans* ; d, *S. equinum* ; e, *S. latipes* ; f, *S. subexcisum* ; g, *S. hirtipes* (after Malloch) ; h, *S. tredecimatum*. The hairs on the sides of the mentum are not shown, but are of diagnostic importance, as described in the text.

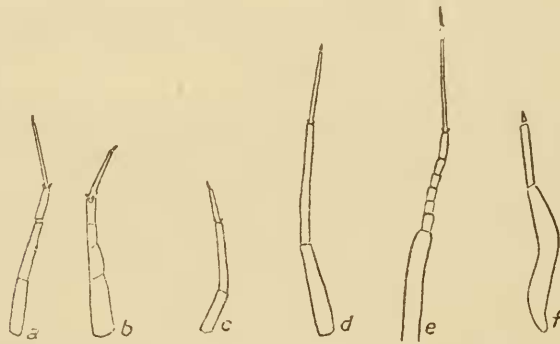


Fig. 3. Antennae of *Simulium* larvae ; all $\times 50$. a, *S. ornatum* ; b, *S. subornatum* ; c, *S. equinum* ; d, *S. latipes* ; e, *S. subexcisum* ; f, *S. hirtipes* (this last after Johannsen).

- Smaller species ; gills with 4-6 (rarely 8) branches ; abdominal banding usually conspicuous ; dark "eyebrow" usually absent ; clypeal markings various but never of the *ornatum* type 11.
10. Thoracic proleg with strong chitinations behind the circle of hooks *variegatum*, Mg.
 These chitinations much less evident ; skin round anus with more numerous scales *monticola*, Fried.

11. Clypeus with a single dark spot posteriorly, or none 12.
 Clypeus otherwise marked 13.
12. A dark area in middle of posterior margin of clypeus, and another on each side
 of the head before the eyes; body colour greenish.. .. . *reptans*, L.
 Head all pale; body colour greyish *tuberosum*, Ldst.
13. A large black mark in the form of an H near the middle of the clypeus; body
 colour yellowish-green *morsitans*, Edw.
 A pair of dark spots on clypeus, more or less connected anteriorly; body colour
 bright green *venustum*, Say.
14. Gills branched; clypeus with six dark spots, not always well defined; "eye-
 brow" without dark dot *latipes*, Mg.
 Gills simple (at least in *S. aureum*); a dark dot in the anterior part of the
 "eyebrow" 15.
15. Clypeus with a median dark streak, more or less interrupted, and four other
 spots *aureum*, Fries.
 Clypeus with eight distinct dark spots, including two transverse bars at each
 posterior corner *angustitarsis*, Ldst.
16. Antennae very long, blackish, 9-jointed; central tooth of mentum simple
 *subexcisum*, Edw.
 Antennae short, pale at least basally, 3-jointed; central tooth of mentum
 strongly trifid *hirtipes*, Fries.

Pupae.

- 1 Prothoracic respiratory organs in the form of thick tubes, the main branches
 of which encircle the thorax at the nearly circular mouth of the
 cocoon *equinum* (L.) Edw.
 Respiratory organs consisting of a number of slender filaments 2.
2. Respiratory filaments with numerous ultimate branches (50-60 or more);
 cocoon a loose shapeless network *hirtipes*, Fries.
 Respiratory filaments with not more than thirteen ultimate branches; cocoons
 closely woven and shaped like the toe of a slipper, usually with semi-
 circular opening 3.
3. Respiratory filaments eight 4.
 ,, ,, six 9.
 ,, ,, four 14.
 ,, ,, thirteen *tredecimatum*, sp. n.
4. Cocoon with a long anterior dorsal projection: the upper two pairs of respiratory
 filaments with long vertical stalks *yerburyi*, sp. n.
 Cocoon without anterior dorsal projection; respiratory filaments otherwise 5.
5. Filaments arranged in four shortly-stalked pairs 6.
 Filaments not in pairs; all rather widely divergent close to the base, towards
 which 3 of them are noticeably thickened *subornatum*, sp. n.

6. Filaments much shorter than the pupa, all of equal thickness, the upper pair shorter than the others ; all four pairs with extremely short stalks ; cocoon with " windows " on each side in front

reptans, L., and var. *galeratum*, n.

Filaments about as long as the pupa ; upper pair slightly thicker but no shorter than the others ; cocoon without " windows " 7.

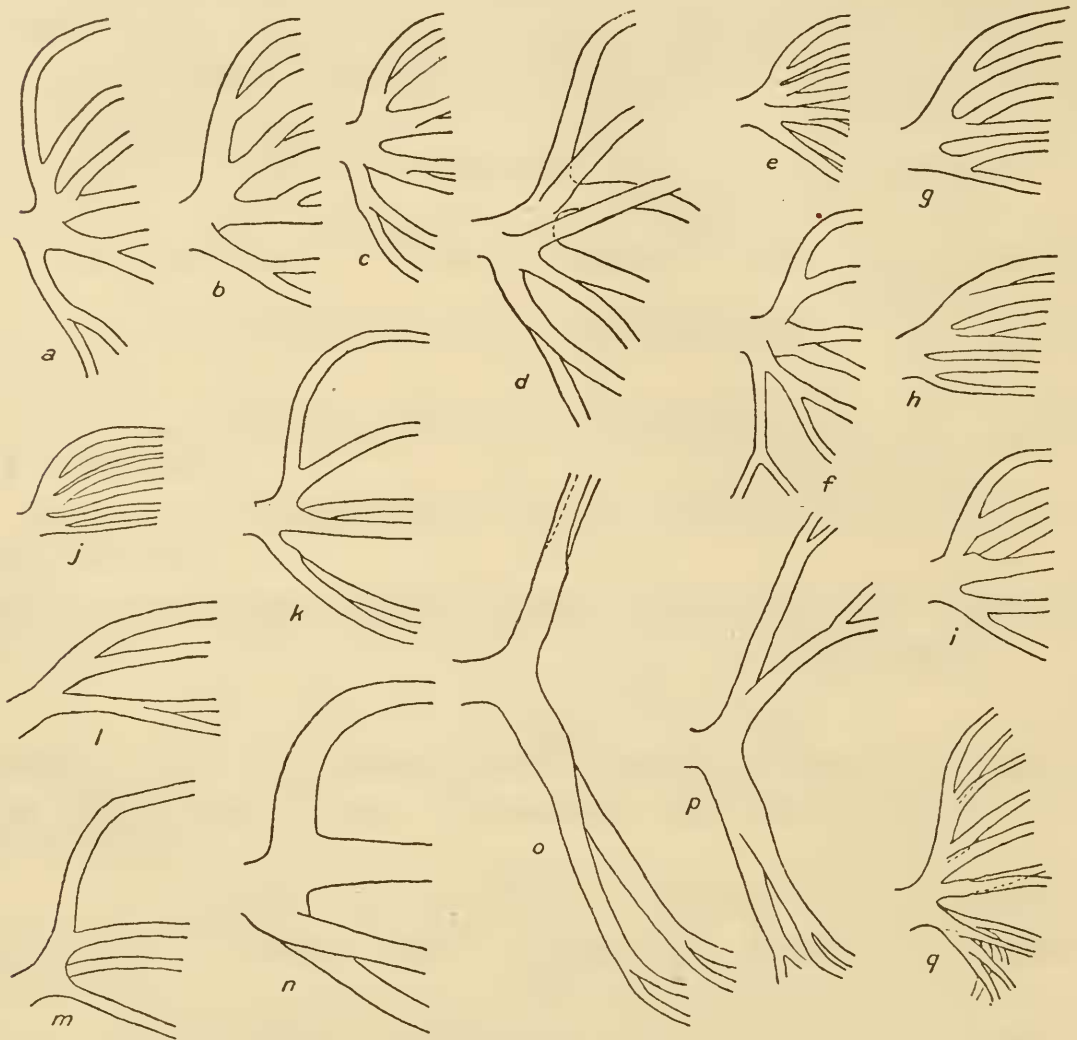


Fig. 4. Bases of prothoracic respiratory organs of *Simulium* pupae, side view, to show branching ; all $\times 35$: a, *S. ornatum* ; b, *S. ornatum*, var. ; c, *S. ornatum* var. *nitidifrons* ; d, *S. subornatum* ; e, *S. reptans* ; f, *S. morsitans* ; g, *S. variegatum* ; h, *S. monticola* ; i, *S. venustum* ; j, *S. tuberosum* ; k, *S. argyreatum* ; l, *S. latipes* ; m, *S. aureum* ; n, *S. angustitarsis* ; o, *S. subexcisum* ; p, *S. yerburyi* ; q, *S. tredecimatum*.

7. The four lower filaments arising from a short common stalk at the base ; then with longer separate stalks, of which that of the lower pair is the longer

morsitans, Edw.

The three upper pairs of filaments separate from the lowest pair at the base 8.

8. The stalks of the two lower pairs of filaments usually longer than those of the two upper pairs *ornatum*, Mg.

All four pairs of filaments with short stalks of about equal length

ornatum var. *nitidifrons*, n.

9. Cocoon with a long anterior projection ; upper pair of filaments with a long vertical stalk ; lower filaments twice dichotomously branched from base
subexcisum, Edw.
 Cocoon without anterior dorsal projection ; filaments otherwise 10.
10. Filaments all widely divergent at the base, the uppermost one nearly vertical for a short distance *argyreatum*, Mg.
 Filaments not widely divergent at base, all more or less in the same vertical plane, arranged in three shortly stalked pairs 11.
11. Filaments somewhat divergent, all about the same thickness ; cocoon all closely woven, as long as the pupa *venustum*, Say.
 Filaments scarcely divergent, the lower pair somewhat thinner than the upper 12.
12. Cocoon short, usually not extending beyond the middle of the thorax ; filaments longer than the pupa, directed straight forwards *tuberosum*, Ldst.
 Cocoon longer than the pupa ; filaments shorter 13.
13. Cocoon all closely woven ; upper pair of filaments considerably thicker than the lower *monticola*, Fried.
 Cocoon loosely woven at the sides in front ; upper pair of filaments not quite so stout *variegatum*, Mg.
14. Filaments in two distinctly stalked pairs ; cocoon with anterior projection
latipes, Mg.
 Filaments all arising from a common base, or nearly so 15.
15. Filaments very stout at the base ; cocoon with anterior projection (short or long) *angustitarsis*, Ldst.
 Filaments slender at the base ; cocoon without anterior projection
aureum, Fries.

1. **S. ornatum**, Mg. (figs. 1a, 2a, 3a, 4a & b).

Larva.—General colour variable, usually greenish grey or dingy greenish-yellow, without special markings on the body. Head light yellowish-brown ; a median wedge-shaped dark mark near posterior margin of clypeus ; a spot on each side of this and sometimes a trace of a fourth anterior to the wedge-shaped mark ; usually also pairs of marks on each side at the posterior margin ; a dark stripe above and in front of the eyes. Antennae 5-jointed ; first joint usually a little shorter than second, which is often very imperfectly separated from the first and sometimes obscurely divided into two in the middle ; fourth longer than third ; last joint very short and conical. Mentum* with three teeth much larger than the others ; between the central tooth and each of the other large teeth are three small ones ; sides of mentum with four to six long hairs. Last abdominal segment without ventral papillae. Anal sucker with about 70 rows of hooks each containing 12–15 hooks about 10 μ long. Anal gills 3, simple. Skin round anus beset with numerous minute scales dark in colour, and plainly visible under a magnification of 100, split apically into a number of spines (3–5).

* Often incorrectly spoken of as the labium.

Pupa.—Respiratory filaments about as long as the pupa, on each side 8 in number, arranged in 4 shortly stalked pairs, the stalks of the two ventral pairs usually the longest; ventral pair slightly thinner than the others; all the filaments more or less in one plane (the vertical). Cocoon tough, closely woven, about twice as long as its breadth in front; height and breadth about equal; anterior margin thickened, but without any forwardly-projecting piece in the middle; no floor to the front half of the cocoon, which has its mouth widely open, and entirely covers the pupa.

Habitat.—Principally a river species, but occurs also in small streams, sometimes even those of a temporary nature. Where water-plants are present, the larvae and pupae attach themselves to the plants, and show a preference for those with long narrow leaves, such as *Sparganium* and water-grasses; *Ranunculus* is less favoured, *Potamogeton* less still; usually the larvae are found chiefly on the lower sides, the pupae chiefly on the upper sides of the leaves. In the smaller streams, where water-plants may be few or absent, the larvae and pupae are to be found on or under stones or on any suitable objects. The species is rarely met with in streams less than 4 feet in width.

Breeding Season.—This species appears to breed in suitable localities all the year round, almost regardless of the season. Pupae have been collected in every month of the year except January, from the middle of February until Christmas. On one occasion (19.ii.1917) fully developed pupae were collected immediately after a period of three weeks continuous frost; these produced adults of both sexes a few days later. I took a newly emerged male in the open on 1st March 1919. There appear to be three main broods, in April, July and September.

Material collected.—Larvae and pupae have been collected as follows:—*Bucks*: R. Misbourne, near Denham, 10.ix.15.; Burnham Beeches, iv. 1916, a few in stony stream with *S. latipes*. *Middlesex*: Harefield, 21.ix.15, in stony and weedy stream; Pinner, 22–24.viii.15. *Surrey*: Beddington, near Mitcham, 31.vii.19; larvae in millions in river Wandle, pupae also numerous, but no adults seen; a few pieces of leaf (totalling one yard in length) of *Sparganium simplex* carried approximately 500 pupae and 4,000 larvae, apparently all of this species. *Devon*: Larvae, and pupae numerous in many small streams in the valleys of the Dart and Teign, up to a height of 1,000 ft.; also in the rivers Otter and Sid, and in small runnels on the sea-cliffs near Sidmouth, vi. 1920. *Hants*: New Forest, 1.v.1920, a few in small streams and in Beaulieu River, in company with large numbers of var. *nitidifrons*; River Test (*M. E. Mosely*). *Herts.*: River Chess, near Chorley Wood, 30.viii.15; River Lea, near Hatfield, v.1916 and 12.iii.1917, on *Ranunculus*; Pegsdon, 21.iv.16, on grass in small stream in “The Meg,” larvae very large and very variable in colour; Hitchin, 5 iii.15, under stones in stream 2–3 inches deep; Radwell, 24.v.20, larvae of all sizes, very variable in colour, also some pupae, on stones in small rapid streams; R. Ivel, near Baldock, vi.1917, on *Ranunculus*, *Sparganium*, etc. *Beds.*: Barton, 21.x.16, under stones. *Cambs.*: Bartlow, Hinxton, and Ashdon, 2.x.15, on grass and willow rootlets in small streams, none on stones in stream bed; Wittlesford, 29.xii.15 and 3.vii.16, larvae on stones in small stream; Stapleford, 28.iv.16, on grass at edge of small stream; Shepreth, 19.ii.17 and 14.iv.17, on *Ranunculus* and *Oenanthe* in small stream; R. Granta, near Hauxton, 7.iv.17, on sedge at edge of river; Cambridge Botanical Gardens, 1.x.15, one pupa with

numerous *S. aureum* on tree-roots in streamlet. *Suffolk*: River Lark, near Mildenhall, 25.iv.16, in large numbers on various water-plants, chiefly *Ranunculus*. *Kent*: Bushyruff, Dover, 21.iii.1898 (*B. L. Hesse*). *WALES*: Anglesey, 19.ix.15, on stones in small stream across field (*C. B. Williams*). *Channels Is.*: Guernsey, Christmas 1910, all stages together (*K. G. Blair*). *Scotland*: near Edinburgh, 27.ix.15, on grass at edges of small stream flowing through fields; current flowing at rate of 6 yards in 10 seconds (*W. Evans*).

Variation.—In some localities the larvae of *S. ornatum* are fairly constant, in others they vary greatly in colour. Thus among 4,000 larvae from Mitcham, roughly examined, no variation was noticeable, while specimens from Pegsdon, Herts., and Harefield, Mx., varied in general colour from almost white to dark greenish, blackish or reddish; occasional specimens have dark brown markings as in *S. aureum*. The head markings are usually distinct, but may be obsolete; very dark specimens sometimes have the head almost all black. The larvae found in small streams seem to exhibit much more variation than those found in rivers, the greatest variation being shown by parasitised larvae. This may possibly indicate that *S. ornatum* is normally a river species, the variation being induced by the change of conditions to those found in small streams.

The pupae exhibit considerable variation in the length of the stalks of the pairs of respiratory filaments, but only in one specimen, out of hundreds examined, was any divergence seen in the number of filaments. This specimen had seven filaments on one side, eight on the other.

The adults vary in size, and as is the case in some other species, the spring broods seem to be larger than the summer ones, though this is not always very marked. The male varies to a remarkable extent in the silvery markings on the thorax, but only individually; a close study of the variation might however possibly indicate the existence of definite local or seasonal forms. One such form has been recognised in the New Forest, and is described below. Most males have the thoracic markings similar to those of the female, and no more conspicuous; some have conspicuous rounded silvery spots much as in the males of *S. reptans*, etc., while I have seen one or two beautifully marked examples with the whole of the margin of the mesonotum silvery, as well as the usual spots. All these are structurally typical; the only other character which I have noted to vary to any extent is the amount of black on the hind tibiae. The chief variation in the female is in the amount of white on the hind margins of the abdominal segments, which is sometimes very conspicuous, outlining three blackish areas on each segment. To this form Curtis' name *trifasciatum* will apply. It is evident that *S. ornatum* is at present a plastic species some derivatives of which have attained stability, while others are probably now in process of development and fixation. It is therefore not surprising that the American representative (*S. piscicidium*) should appear to be specifically distinct.

Blood-sucking.—Since my previous notes on this subject were published, I have had abundant evidence that this species is a blood-sucker, but it would appear not to bite except on warm and rather still days, chiefly in the afternoon sun. Mr. C. L. Walton sent me some specimens from Crosswood, Cardiganshire, which he took in August 1916 attacking horses about the nose and eyes. I have also taken *S. ornatum*

(Letchworth, 5.iv.18) on horses' bellies, and (Letchworth, 19.x.17) in numbers on calves' bellies, some containing blood. Besides this I have frequently taken females, sometimes apparently gorged, in cowhouses. Mr. W. Evans has noted the species biting his hand. I have also myself received bites from them on my nose, eyebrow and hand (25.iv.16, 19.x.17, 15.xi.17, 5-18.iv.19). The bites were not particularly painful and left no after-effects; most of them were inflicted while I was in a stooping position (*e.g.*, when gardening), and I frequently noticed that the flies were more in evidence then than while I was standing. Perhaps they mistake a man stooping for a horse or cow, which would seem to be their normal hosts.

References.—The early stages of this species have been described in more or less detail by a number of writers. The best figure of the pupa is that of Castellani and Chalmers (Manual of Tropical Medicine, Ed. iii. p. 812); the figure is not named specifically as that of *S. ornatum*, but is quite unmistakable. A larva and pupa of *S. ornatum* have also been figured by Kollar (Sitzb. k. Akad. Wiss. Math.-Nat. Kl. i, pp. 92-107, pls. i-iii, 1848, under the name *S. sericeum*, Mg.); Grünberg (Die Süßwasserfauna Deutschlands, 2a, p. 107, figs. 128-130, 1910); Verdat (Naturw. Anz. allg. Schweiz. Ges. v, p. 65, 1822—as *S. sericea*); Liebe (Zeits. Naturw. 82, p. 345, 1910—larva only); Meinert (K. Danske Vid. Selsk. Skr. (6) iii, p. 373, 1886). The most recent writer is Friederichs (Zeits. f. angew. Entom. vi, pp. 61-83, 1919), who figures the male hypopygium and the pupal filaments of this species as *S. reptans*; with this use of the name *reptans* I cannot agree. It is not clear what species he would indicate as *S. ornatum*; possibly the one described below as *S. subornatum*.

1a. ***S. ornatum* var. *nitidifrons***, nov. (fig. 4c).

Closely resembles *S. ornatum*, Mg., except that the frons of the female is shining and not dull; the mesonotum of the female appears distinctly more shining than in the typical form; and there is little or no white on the hind margins of the abdominal segments. The male does not differ perceptibly from that of *S. ornatum*. Larva with the head markings rather more distinct. Pupa with eight branches to the respiratory organs, all about equal in diameter, arranged in four pairs, all almost sessile or with very short stalks of about equal length.

This form was abundant in the New Forest at the beginning of May 1920; larvae and pupae were collected on different water-plants in the Brockenhurst River, the Beaulieu River, and some small streams running into the latter. In the small streams it was the most abundant form. Specimens of the normal form of *S. ornatum* were also reared from the same streams, but these were comparatively scarce. A few females were taken on the wing at Gidleigh Park, S. Devon, 2.vi.1920, but no larvae or pupae were found. Both sexes were reared from pupae found in company with *S. ornatum* near Shelve, Salop, vii.1920, on grass in a small stream. Dr. G. Enderlein has since sent me specimens of both sexes (identified as *S. reptans*) from Berlin; he also sent specimens, probably from the same batch, to Friederichs, who has described them as *S. reptans*.

This form bears a great resemblance to the Scotch and Welsh *S. monticola*; the latter is regarded as a distinct species, since it differs markedly from *S. ornatum* in the larvae, pupae and male hypopygium, whereas the New Forest form apparently does not.

2. *S. subornatum*, sp. n. (figs. 1c, 2b, 3b, 4d, 7b).

Adult.—Male: Thorax black, with fine golden pubescence and double silvery markings in front as in typical *S. ornatum*. Membranous area of pleura bare. Silvery markings on the sides of the abdomen not very conspicuous, but extending on to the 8th segment as well as the 6th and 7th (which is not the case in *S. ornatum*). Genitalia resembling those of *S. ornatum*, but the stylus of the adminiculum (viewed from beneath) is much longer and narrower, more like *S. reptans*, but distinctly pubescent. Front tibiae silvery; front tarsi thickened, the metatarsus about $5\frac{1}{2}$ times as long as broad. Middle tibiae yellow at the base. Hind tibiae and metatarsi practically all black or dark brown, the latter moderately swollen.

Female: Face and frons dull grey. Thorax marked as in *S. ornatum*, but rather less distinctly; pubescence of mesonotum finer. Abdomen with the first five segments dull, blackish, with white hind margins, the last three moderately shining, but rather less so than usual. Legs coloured practically as in *S. ornatum*, but rather less brightly; middle and hind tibiae sometimes with traces of dark rings near the base, especially on the under-side; claws simple. Other characters as in the male.

Larva.—Head markings similar to those of *S. morsitans*, but the H is not so dark and much less distinct. Abdomen without distinct banding. Antennae apparently 6-jointed, but the first four joints not very distinctly separated; the first about as long as the second and third together, the second, third and fourth about equal in length. Mentum with 9 pointed teeth in the terminal row, the middle one and the one at each end larger. Sides of mentum with 5 or 6 long hairs. About 80 rows of hooks in the anal sucker, 12–15 hooks in each row. Skin round anus with a number of minute spines or scales, which are smaller, less numerous and less conspicuous than those of *S. ornatum*. No ventral tubercles on last segment. Anal gills retracted in all specimens examined.

Pupa.—Respiratory filaments 8 in number, the upper four rather widely divergent at the base, not arranged in pairs; the uppermost one nearly vertical for some distance; the upper three arise from a common base or a very short common stalk; the next one is somewhat isolated; the remaining four are in two pairs with very short stalks; the three filaments on the inner side of the bunch are rather distinctly thickened towards the base. Cocoon differs from that of *S. ornatum* in being more loosely woven, with “windows” on each side in front.

Material collected.—I first recognised this species from two females sent me from Bayswater, Oxford, 15.vii.16 (*A. H. Hamm*); the same collector subsequently obtained a third at the same place, 8.vi.18. About 10 ♂ and 5 ♀ were received for determination in 1917 from Bulwell Hall Park, Notts., 21.vi.16. and 18.vii.16 (*J. W. Carr*). Some of these were presented to the British Museum, and I designate one of the males as type. I myself found a small swarm of the males hovering under a lime tree at Norton Bury Farm, Letchworth, 16.vi.17, and again at exactly the same spot on about the same date in 1918; in each case all the members of this swarm were this species, although *S. ornatum* was swarming under another tree close by; I also obtained a single male by the river Severn at Shrewsbury, 24.vii.1920. A scrutiny of the series of *S. ornatum* in the British Museum revealed a single male of *S. subornatum* from Llangammarch Wells, Brecknock (*Lt.-Col. Yerbury*). Finally

Mr. M. E. Mosely has presented to the British Museum a number of pupae and a few larvae; masses of the former were in a jar in Mr. Mosely's possession collected by the late F. M. Halford and labelled "Crickmere, 16.ix.1894;" Mr. Mosely also collected a few pupae himself in the River Test, Hants.

The species must be very similar to the North American *S. piscicidium*, but that is described as having yellow legs.

3. *S. variegatum*, Mg. (figs. 1*b*, 4*g*).

Larva.—General colour brownish or dark grey, without special markings on the body. Head usually dark at the sides above and below the eyes; clypeal markings often faint, when present usually ill-defined, but arranged much as in *S. ornatum*. Antennae 5-jointed, the first as long as the next two or three together; second sometimes indistinctly divided in the middle, twice as long as the third; third shorter than the fourth. Mentum with 9 teeth in the terminal row, all slightly trilobed, the small lateral lobes pale; middle tooth very large; about 8 long hairs on each side almost in a straight line. Thoracic proleg with a pair of rather strongly chitinised plates above the ring of teeth. Last abdominal segment without ventral papillae. Anal sucker with about 85 rows, each with 12–15 hooks. Anal gills each with 8–10 rather long branches. Skin round anus with numerous minute dark scales, composed of short rows of spines (5–8 in each); the scales are much smaller and less numerous than those of *S. ornatum*.

Pupa.—Respiratory filaments about as long as the pupa, six in number, in three very shortly stalked pairs; all the filaments more or less in the same plane; upper pair rather thicker than the others. Cocoon very large, fully a third longer than the pupa, in texture close-woven behind and above, but with an open network on the sides towards the front; this network often, but not invariably, continued round the front of the cocoon and enclosing the ends of the respiratory tubes, the cocoon then approaching the "boot"-shape of *S. equinum*.

Habitat.—Swift stony rivers and streams, both larvae and pupae on the upper surfaces of stones where the current is strong but smooth and the water not too deep.

Material collected.—Larvae and pupae were found in great abundance in early June 1920 in South Devon: in the River Dart through Holne Chase, the River Teign between Fingle Bridge and Christow, and the river Yeo near Ashburton, associated with *S. tuberosum* and *S. reptans* but in much larger numbers. A female specimen hatched from a pupa collected in 1912 at Ewbank Scar, Kirkby Stephen, Westmoreland (*C. B. Williams*), in company with larvae and pupae of *S. monticola*, Fried.

Blood-sucking.—In August 1916 Mr. C. L. Walton sent me females from Crosswood, Cardiganshire, which were taken in company with *S. ornatum* "attacking horses about nose and eyes and on belly."

Variation.—There seems to be great variation in the colour of the larval head, some being much darker than others.

Reference.—Friederichs has described the larva, pupa and adult of this species as *S. venefica*, sp. n.

4. *S. monticola*, Fried. (figs. 1b, 4h, 5a).

Adult.—Resembles *S. ornatum* in all respects except the following :—Membranous area of pleura bare ; front metatarsi about $6\frac{1}{2}$ times as long as broad ; male genital claspers broader, the external margin convex in the middle ; frons of female blackish, moderately shining ; abdomen of female entirely black. From *S. variegatum* the main if not the only differences are the shape of the male claspers, and the shining frons and dark femora of the female. This description agrees with that of *S. arcticum*, Mall., described from the female only from British Columbia, but without definite proof the two can hardly be considered the same.

Larva.—General colour dirty greenish-grey, with obscure darker abdominal banding (on first 5 segments). Head very dark at the sides, except just round the eye-spots ; clypeus dark on its posterior margin, in the middle with a short dark longitudinal mark in contact with the dark margin, and slightly anterior to this a pair of inconspicuous dark spots. Antennae as in *S. ornatum*. Mentum with 9 teeth in the terminal row, the central tooth and the one at each side rather larger than the others ; sides of mentum with 8–10 long hairs. No ventral papillae on last abdominal segment. Anal sucker with about 100 rows, each containing 15–18 hooks. Skin round anus as in *S. ornatum*. Gills each with about 8 branches.

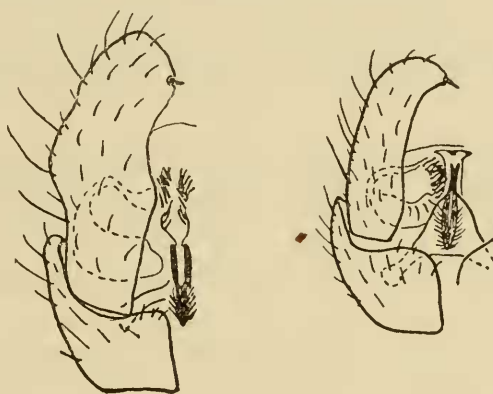


Fig. 5. Male hypopygium, seen from beneath :
a, *S. monticola* ; b, *S. subornatum*.

Pupa.—Respiratory filaments barely as long as the pupa, six in number, arranged in three pairs with very short stalks ; all the filaments in a vertical plane ; upper pair slightly swollen at the base and thicker than the other two pairs. Cocoon as in *S. ornatum*.

Habitat.—Moderately small swift streams, usually on rocks or stones ; both larvae and pupae usually on the upper or down-stream side. Sometimes present on stones covered with moss.

Breeding Season.—The first brood hatches in May, and there is certainly another brood, since a gravid female was taken near water in the middle of June, and full-grown larvae have been found in August.

Material collected.—The species was fairly common in most of the small burns in the north half of the Isle of Arran, 22.v.–7vi.19 ; there were few larvae left by the end of this time. A specimen was also taken in a wooded valley at Ffrith, Flintshire, 10.vi.19, and in the stream near by were numerous small larvae, possibly representing a second brood of this species. One or two specimens were reared from pupae

collected on stones in a rapid mountain stream at Kirkby Stephen, Westmoreland, 22.vii.1912 (*C. B. Williams*). Inverleithen, near Peebles, 7.viii.1910, adult males on the wing, larvae of various sizes and some pupae on stones and some on grass (*Dr. J. Rettie*, per *Dr. J. H. Ashworth*). Various streams in the neighbourhood of Pontesbury and Church Stretton, Salop, vii.1920.

Blood-sucking.—No definite evidence, but a few specimens (of both sexes) entered tent.

References.—Friederichs, in the paper cited in the introduction (Oct. 1920), describes this species from the Harz Mountains. I have distributed it to various correspondents under the MS. name *obreptans*.

5. ***S. reptans***, L. (figs. 1*d*, 2*c*, 4*e*).

Larva.—General colour greyish. Head with a single dark spot of varying size and shape in the middle of the posterior margin of the clypeus; no dark mark above eye-spots. Abdomen with conspicuous dark greenish bands on all the segments dorsally, those on 6–8 nearly confluent. No ventral papillae on last segment. Gills each with 4 to 5 short branches. Skin round anus with numerous minute almost colourless simple scales. Teeth of mentum rather blunt, the nine in the terminal row all slightly trifid, the small lateral lobes pale. Antenna 5-jointed, gradually tapering to the end of the 3rd; first scarcely as long as the next two together, second nearly twice as long as the third. About 75 rows of hooks in the anal sucker, 12–15 hooks in each row.

Pupa.—Respiratory filaments much shorter than the pupa, 8 in number on each side, spreading but little from the vertical plane; arranged in 4 very shortly stalked pairs; uppermost pair rather shorter than the others; all the stalks equal in length and all the filaments of equal diameter, slightly and evenly tapering towards the tips. Cocoon as in *S. ornatum*, except that on each side towards the front there is a rather large open space, usually crossed horizontally by one or two bands of silk.

Habitat.—Swift shady rivers in mountainous regions, but not at high altitudes. Where water-plants (such as *Ceratophyllum*) are present the larvae and pupae occur on them in some numbers, but are most typically found on the flat upper surfaces of large stones where the current is strongest, and particularly in those places where the flow is smooth and even and where there is no great depth of water. No larvae were found in the bare valleys above the tree-line, and very few in places where the rocks were much covered with moss.

Breeding season.—The first brood of the year does not appear until the end of May or the beginning of June. I have had no opportunity of ascertaining whether there is a second brood, nor what is the method of over-wintering.

Material collected.—The species was abundant in Machrie Water and in the burn flowing through Brodick Woods, Arran, v–vi.1919, in company with *S. tuberosum*. It did not occur in the smaller burns on the island. Also found in Devonshire, in small numbers in the Upper Teign and in the Yeo near Ashburton, and more numerous in the Otter at Tipton St. John and in the Sid at Sidmouth, in the former case in company with large numbers of *S. variegatum*, and in the latter with *S. ornatum* and other species, 1–18.vi.1920. A single male was taken on the wing near Church Stretton, Salop, 21.vii.1920.

Variation.—None noticed, except, as already mentioned, the size of the single dark spot on the head of the larva.

Blood-sucking.—I have little to add to my previous notes except that up to the time I left Arran (5.vi.19) I was not attacked, and no females were even seen on the wing in Devonshire (up till 17th June). Probably the insect requires to be on the wing for some time before proceeding to its blood meal. Mr. P. H. Grimshaw writes "The specimens from Rannoch repeatedly flew at my face, in fact chiefly at my eyelids, and proved very irritating. They did not actually bite, but possibly would have done if I had given them the chance."

5a. ***S. reptans*** var. ***galeratum***, nov. (fig. 1e).

Adults.—Not positively identified, but probably identical with *S. reptans*.

Larva.—General colour light greenish, with darker but not very conspicuous transverse bands on the abdomen. Head yellowish, clypeus with a black spot in the middle of the posterior margin, connected anteriorly with a large roundish black mark which occupies almost the entire breadth of the clypeus; its edges are not very sharply defined and it has a small anterior emargination. A dark rim above and behind the eye-spots, sometimes entirely surrounding them. Antennae apparently only 4-jointed, the first joint longer than the remaining three together, second about equal to the third (the division between what are usually the first two joints seems to have disappeared). Mentum as in *S. reptans*. The pigment-spots within the sides of the sixth and seventh abdominal segments are darker and more conspicuous than usual. No ventral papillae on last abdominal segment. Gills either quite simple or with one or two (rarely three) short branches. Skin round anus with a few minute colourless scales. About 65–70 rows of hooks in the anal sucker, 10–15 hooks in each row.

Pupa.—Apparently indistinguishable from that of *S. reptans*. The respiratory filaments as dissected from the fully developed larva are as in *S. reptans*, and the single pupa collected that can with certainty be referred to this species (owing to its still retaining the larval head-capsule) showed no obvious difference either in the pupa itself or in the structure of the cocoon from *S. reptans*. This pupa was unfortunately not isolated, and the adult issuing was lost among a number of *S. reptans*.

Material collected.—Larvae were abundant on stones and water-plants (*Sparganium*, etc.) in the river Otter at Tipton St. John, S. Devon, 14.vi.1920, in company with many *S. ornatum* and *S. reptans*, and a few *S. equinum* and *S. aureum*.

Although this species was the most abundant in the larval state, even more so than *S. ornatum*, no adults were reared from pupae which could be correlated with these larvae, all the specimens obtained being either *S. reptans* (in the largest numbers), *S. ornatum* or *S. equinum*. This would seem to suggest that the form under consideration may be only a local form of *S. reptans* which has developed distinct characteristics in the larval state only; but against this it must be stated that a small number of larvae were obtained at the same time and place which agreed in every respect with the Scotch form of *S. reptans* as described above. Moreover, in the river Teign, and even in the Sid, two or three miles distant, only normal

larvae of *S. reptans* could be found. Since, however, the only structural difference between this form and *S. reptans* is in the simple or less branched gills, it seems on the whole most probable that it is a variety of *reptans*, and I have so regarded it pending further investigation. The name has reference to the cap-like black patch on the head of the larva, a most striking feature.

6. ***S. morsitans***, Edw. (figs. 1*f*, 4*f*).

Adult.—Both sexes have now been obtained by breeding. The female is very difficult to distinguish from that of *venustum*; there seems to be no constant difference in the colour of the base of the abdomen, as I previously thought, but this species may perhaps be separated (in the female sex) by the greater amount of yellow on the middle tibiae. The only clear distinction in the adult, however, appears to be in the shape of the male claspers.

Larva.—General colour rather pale yellowish-green without distinct darker markings. Head yellowish, the clypeus with a conspicuous and rather sharply defined black mark in the form of an H. Antennae 4-jointed, the second joint a little longer than the first, third scarcely as long as second, fourth minute. Mentum with 9 teeth in the terminal row, the middle one long, the one at each end very broad, intermediate ones indistinctly trilobed; four or five long hairs at the sides. Last abdominal segment without ventral papillae. Anal sucker with 65–70 rows of hooks, about 15–20 in each row. Skin round anus bare. Gills with 5 or 6 branches all approximately equal in size.

Pupa.—Respiratory filaments 8, about as long as the pupa, in four pairs, the two lower pairs slightly thinner than the upper, and arising from a short common stalk; each of the four pairs also with its own stalk, that of the lowest pair distinctly, often much, longer than the others; all the filaments in the vertical plane, not at all swollen towards the base. Cocoon as in *S. ornatum*.

Habitat.—Weedy rivers of moderate current in company with *S. ornatum*, *S. venustum* and other species. Not found as yet in small streams.

Breeding season.—There may be two broods in the year, as adults have been obtained in May and July, but the May brood is certainly the more numerous.

Material collected.—Two males were reared from pupae found in the river Granta at Hauxton, Camb., 5.vii.15, on *Scirpus* in company with large numbers of *S. equinum* and *S. argyreatum*. A fair number of larvae and pupae were found on grass and *Ranunculus* at the edge of the Lymington River, near Brockenhurst Bridge, New Forest, 2.v. 20.

7. ***S. venustum***, Say (*austeni*, Edw.) (figs. 1*g*, 4*i*).

Adult female.—A number of females have been obtained by rearing; they appear to differ from those of *S. morsitans* as shown in the table. I have failed to discover a better distinction.

Larva.—General colour bright green, the abdomen with rather indistinct bands of darker green. Head light in colour, with a pair of somewhat oval dark spots at some distance from the neck, lying close together, connected at or near their anterior ends by a transverse bar; usually also a dark area along the posterior margin of the clypeus. (The areas which in most species are dark are here pale, with dark areas

more or less surrounding them.) Antennae and mentum as in *S. morsitans*, the mentum however with a broader black terminal portion. Anal sucker and gills as in *S. morsitans*. Skin round anus with some very minute scales, inconspicuous even under a magnification of 300.

Pupa.—Respiratory filaments about as long as the pupa, six in number, arranged in three distinctly stalked pairs, the stalk of the uppermost pair nearly vertical, slightly longer and thinner than that of the middle pair. All the filaments in the vertical plane at the base, slightly and evenly tapering towards the tips, bases not at all swollen. Cocoon as in *S. ornatum*.

Habitat.—Weedy rivers of moderate current.

Breeding Season.—The first brood appears at the end of April; we have yet no clear evidence as to whether there is a second. A very few adults have been captured in August, and Miss F. Collins collected eggs in May 1911 at a spot where *S. venustum* was abundant, but these may have belonged to some other species.

Material collected.—Larvae and pupae: New Forest, Hants., 1–3.v.1920; numerous on grass and *Ranunculus* in Lymington River at Brockenhurst Bridge, also a few specimens in small streams running into Beaulieu River. Pupae: West Moors, Dorset, v.1911 (*Miss F. Collins*); R. Granta near Cambridge, 28.iv.16, on *Ranunculus* with *S. equinum*; Stapleford, Cambs., 28.iv.16, one on grass at edge of stream, with *S. ornatum*. Adults, additional localities: Horley, Surrey, v.15 (*G. A. H. Bedford*); Oxford district, v.16 (*A. H. Hamm*); Letchworth district, v.17, v.18, v.19, often at considerable distances from the nearest possible breeding places, some males as far as two miles; New Forest, 1–3.v.20, numerous in various localities, males swarming, females entering tent; Shrewsbury, 21.vii.20, one female.

References.—The pupa described and figured by Otto Fabricius (*Schriften der Berl. Ges. Nat. Freunde*, v, 1784, pp. 254–259, pl. iv) as that of *S. sericea*, Linn., may possibly be this species. Fabricius found the pupae in July on *Potamogeton lucens* in Norwegian rivers.

A pupa figured (though not named) by Vogler (*Mitt. Schweiz. Ent. Ges.* vii, p. 279, 1886) is almost certainly *S. austeni*. Vogler found it in company with *S. equinum* (which he also figures) on *Ceratophyllum* and other water-plants in the river Rhine.

S. austeni is so extremely closely allied in all stages to the North American *S. venustum*, Say, as figured by Malloch and Pomeroy, that it cannot be ranked as more than a local race. I have compared the genitalia of British specimens with those of a specimen from Spartanburg, S.C. (*A. W. Pomeroy*) and can find scarcely any difference. Both males and females are otherwise indistinguishable, and there is no structural difference in the larvae or pupae. Even the head markings of the larva are of the same type, though most of the British specimens examined had the dark markings developed to a somewhat less extent; examples could probably be found however to match Pomeroy's figure exactly. Though structurally identical, the two races seem to have developed biological differences. Pomeroy states that in America *S. venustum* female is abundant from early spring to late autumn in the ears of horses, and that there are three or four broods in the year. In this country, as mentioned above, there seems to be normally only a single brood, while no examples have so far been found in horses' ears.

8. *S. tuberosum*, Lundstr. (fig. 4j).

Larva.—General colour dingy greyish or greenish grey; head pale above, without dark markings; abdomen with dark dorsal bands on the first five segments, the first two sometimes interrupted; segments 6–8 all dark above. Antennae as in *S. reptans*. Mentum with 9 teeth in the terminal row, all simple, the middle one and the one at each end considerably larger than the others. Anal sucker with about 80 rows, each containing 12–15 hooks. Skin round anus bare. No ventral papillae on last segment. Gills each with from 6 to 8 branches.

Pupa.—Respiratory filaments 6, in three pairs, each pair distinctly stalked; filaments much longer than the pupa and all directed nearly straight forwards; the two ventral pairs appear to be given off from the main stem which terminates in the dorsal pair. Cocoon constructed as in *S. ornatum*, but smaller, both actually and relatively to the pupa, rarely extending beyond the middle of the thorax.

Habitat.—With *S. reptans*.

Breeding Season.—As in *S. reptans*.

Material collected.—The species was very numerous in Machrie Water and Brodick Wood Burn, Arran, v–vi.1919, in the latter much more abundant than *S. reptans*, though in the former *S. reptans* predominated to some extent. Also found in Devonshire, in small numbers in the river Dart at Holne Chase, and the river Teign below Fingle Bridge. The occurrence of this species and of *S. reptans* so far south is of interest, and was somewhat unexpected, but their association with hilly country is confirmed.

Variation.—None noticed, except to a slight extent in the size of the cocoon.

Bloodsucking.—No further data available.

9. *S. argyreatum*, (Mg.) Lundstr. (figs. 1h, 4k).

Larva.—General colour rather reddish grey. Back of head with four distinct rather elongate dark spots, the posterior one darker than the others, usually all enclosed in a dark cloud; dark eyebrow present, but without any included darker dot. Abdomen with a conspicuous dark band on each segment. Antennae as in *S. reptans*. Mentum with 11 teeth in the terminal row, the middle one and the second from each end somewhat larger than the others. Anal sucker with about 80 rows, each containing 14–18 hooks. Skin round anus with a very few simple scales. Very small ventral papillae on last segment. Gills simple.

Pupa.—Respiratory filaments 6, about as long as the pupa, not arranged definitely in pairs, but all arising almost from a common base and spreading out considerably at the base in all directions; the uppermost one a little thicker than the other five, its basal part approaching the vertical. Cocoon as in *S. ornatum*.

Habitat.—Weedy rivers with only a moderate current, usually associated with *S. ornatum* or *S. equinum* or with both these species. The larvae and pupae seem particularly fond of the leaves and stems of *Scirpus lacustris*, and of other plants with ribbon-like leaves, though they are by no means confined to these plants. The larvae predominate on the lower sides, the pupae on the upper sides of the leaves.

Breeding Season.—The larvae of the first brood become full-fed about the end of March, the flies appearing early in April, or possibly in March in some cases. Development must be rapid after this as second-brood specimens have been taken as early as the 25th April. On the other hand, first brood specimens have been taken as late as 9th May (*A. H. Hamm*). The main second brood, however, appears at the end of June, and seems to be the most numerous in individuals. There is certainly also a third and perhaps a fourth brood. I have so far been unable to discover the species in any stage in the winter. The oviposition has not been observed.

Material collected.—Larvae and pupae have been collected as follows:—*Cambs.*: River Granta at Hauxton, 5.vii.15, on *Scirpus lacustris*; 7.iv.17, on sedge at river's edge; Shelford, i.vii.15. *Suffolk*: River Lark, near Mildenhall, 30.ix.15 and 25.iv.16, on *Ranunculus* and *Sparganium*. *Herts.*: River Ivel near Radwell. *Beds.*: Cardington Mill, 28.vi.15, on leaves of *Scirpus* and *Sparganium*. *Hants.*: River Test (*M. E. Mosely*). Mr. H. Garnett has also sent me specimens taken near Evesham flying in clouds over the River Avon, in which thousands of *Simulium* larvae were living.

Variation.—None has been detected in the larvae or pupae, but for the reasons stated in the introduction I have come to the conclusion that these are two well-marked seasonal forms of the adult, the first representing the spring brood, the second the subsequent broods. These can be distinguished as follows:—

Spring form (var. *sericatum*)*: Length of body 3–3·5 mm. Markings of male thorax not silvery, only dull greyish; the two patches towards the front of the mesonotum are produced backwards as two rather narrow lines as far as the scutellum and the thorax might therefore be described as greyish with three broad black stripes. Female thorax only moderately shining; when viewed from in front it shows fairly evident traces of two longitudinal greyish stripes. Front coxae of female black, grey-dusted.

Summer and autumn form (*argyreatum*): Length of body 2–2·5 mm. Markings of male thorax silvery, especially when viewed from in front, consisting of a pair of more or less triangular patches, with their apices directed backwards. Female thorax rather brightly shining, without a trace of longitudinal stripes. Front coxae of female reddish, grey-dusted.

Blood-sucking.—Further experience only confirms the view that this species is a habitual blood-sucker. At Mildenhall, 25.iv.16, it was in great numbers and very troublesome to a distance of quite half a mile from its breeding place, biting both head and hands. Though, to judge from the relative abundance of pupae, this species was much less numerous than *S. ornatum*, by far the greater proportion of the bites were inflicted by it, and I also noticed that *S. argyreatum* commenced its attacks much earlier than did *S. ornatum*. Other records were obtained in the Letchworth district, e.g., 18.iv.1919, bites on hand and ear. These were chiefly if not all of the spring form, but Mr. A. H. Hamm has provided me with several records of the summer form biting in the Oxford district (23.ix.16, 6.vi.17).

* M. Ségué notes in regard to Meigen's type of *S. sericatum*, "Détruit, le débris qui reste répond bien à votre description ♀." He also states that the types of *S. argyreatum* and some others "répondent bien à vos tableaux."

References.—It is possible that *S. argenteostriata*, Strobl, as described by Corti (Atti Soc. Ital. Sci. Nat. liii., p. 192, and liv, p. 223, 1914–16) is the spring form of this species, but I have not seen Italian specimens. The pupal filaments have recently been figured by Friederichs (Zeitschr. f. angew. Ent. vi, p. 61, 1919).

10. *S. equinum* (L.) Edw. (figs. 1*i*, 2*d*, 3*c*, 6*a*, *b* & *c*).

Larva.—General colour rather bright green, body-markings darker green, but not conspicuous. Head with 6 distinct dark spots, 4 arranged as usual in the form of a cross, the other two being on the posterior margin of the clypeus. No dark stripe above the eyes. Antennae rather slender, 4-jointed; the second joint nearly twice as long as the first or the third, which are about equal in length; fourth minute. Mentum with 9 simple teeth in the terminal row, the central one and the one at each end much larger than the others. About 100 rows in the anal sucker, each with 20–25 hooks. No ventral papillae on last segment. Skin round anus bare. Anal gills simple.

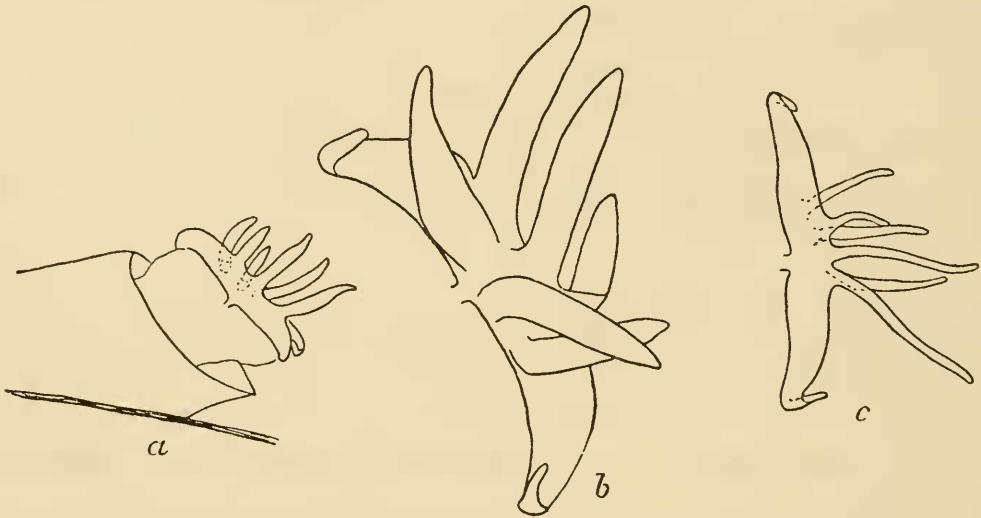


Fig. 6. *Simulium equinum*, L.: *a*, pupal skin of a hatched specimen projecting from mouth of cocoon, $\times 10$; *b*, respiratory organ of left side, seen from the right, $\times 25$; *c*, variety of pupal respiratory organ, $\times 25$, from a specimen found in the River Test by Mr. M. E. Mosely.

Pupa.—Respiratory organs consisting of thick tubes instead of long thin filaments. Close to the body of the pupa the organ divides into a dorsal and a ventral section, which are entirely in contact with the pupa on the one side and with the cocoon on the other. The tips of these dorsal and ventral sections are abruptly narrowed and slightly overlap those of their fellows of the opposite side. From the dorsal section there project forwards five rather short and stout branches, two on the outer side and three on the inner; the ventral section gives off a single branch near its base; these branches are not more than one-third of the length of the pupa. Including the tips of the main sections, there are thus eight branches in all. The chitin forming the tubes is very thin and usually bears minute spines scattered over its whole surface, visible as dark dots under a magnification of 100. Cocoon closely woven, somewhat boot-shaped, that is to say, the anterior part of the floor is raised at an angle with the remainder, the opening being practically circular; anterior margin not thickened.

Habitat.—Weedy rivers with only a moderate current, usually associated with *S. argyreatum* and sometimes also *S. ornatum*, on various water-plants, to a depth of 6–9 inches, the larvae mainly on the lower or down-stream side of the leaves, the pupae mainly on the upper or up-stream side.

Breeding Season.—There are probably three main broods in the year, in March or April, July and September. No evidence has so far been obtainable as to the method of over-wintering, the earliest date on which larvae or pupae have been collected being 7th April, and the latest 10th September. Females, however, have been captured on the wing as early as February, and specimens of both sexes, obviously newly hatched, at the beginning of April.

Oviposition.—Mr. H. Britten has given (*Ent. Mo. Mag.* May 1915) some interesting notes on the oviposition of this species, and in May 1919 I was able to confirm his observations, watching the females enter the water for the purpose of laying their eggs. In this case the eggs were deposited on a dead willow branch which was lodged in the river Ivel near Sandy, Beds. The insects chose a spot which was entirely sheltered from the current in order to enter the water, walked in to a depth of several inches and laid their eggs on the lower side of the branch. As Newstead noticed in the case of *S. ornatum*, the wings were wrapped round the abdomen and confined a layer of air between them and the body. Oviposition completed, the insect walked to the down-stream side of the branch, let go its hold and rose to the surface in its bubble of air. Some specimens took to flight the moment they reached the surface, others floated on the water for a few seconds before being able to rise.

The eggs of *S. equinum* are not, like those of other species, enclosed in a hard gummy matrix, but in soft jelly like those of many CHIRONOMIDAE. They are however placed close together in a single layer.

Material collected.—Larvae and pupae have been obtained as follows:—*Bucks.*: R. Misbourne, near Denham, 10.ix.15; R. Colne, near Denham, and stream in Denham village, 26.viii.15, larvae of all sizes and pupae, chiefly on water-plants, a few on stones. *Herts.*: R. Chess, near Chorley Wood, 30.viii.15, immature larvae; River Lea at Hatfield, v.1916, on *Ranunculus*; River Ivel at Radwell, various dates. *Cambs.*: River Granta at Hauxton, 5.vii.15, in immense numbers on *Scirpus* and *Potamogeton*; also at Shelford, 1.vii.15 and v.17, and Grantchester, 28.iv.16, on *Ranunculus*; Hauxton, 7.iv.17, numerous pupae and some larvae in one patch only on sedge at side of river. *Suffolk*: River Lark, near Mildenhall, 25.iv.16, on *Ranunculus*, etc.; numerous ♂♂ hovering in shade, but scarcely any ♀♀ seen on the wing, and none bit. *Hants.*: Bournemouth (*D. J. H. Ashworth*); River Test (*M. E. Mosely*). *Devonshire*: In small numbers in the River Otter at Tipton St. John and in the River Sid at Sidmouth, mostly on water-plants, a few on stones.

Variation—None noticed in larvae. In the pupae the minute spines on the surface of the respiratory organs are sometimes absent. The adults of the spring brood appear to be decidedly larger than those of the subsequent broods; there is also much variation in the colour of the thoracic and abdominal pubescence of the females, some specimens being much more golden than others; possibly the spring brood might be distinguishable by being on the average less brightly coloured. The

dark stripes on the thorax of the female vary in width and distinctness, being hardly distinguishable in very dark specimens; the legs are much darker in some specimens than in others.

Examples from the Mediterranean region (*e.g.*, those recorded in my previous paper from Fez) differ in the paler colour of the pubescence of the thorax in the female. Some pupae of this form collected by Capt. J. Waterston in Macedonia differ from the British forms in having the six minor branches of the respiratory organs longer, more slender, and closer together at the base. The larvae are alike. A single half-developed female pupa of this form has recently been given me by Mr. M. E. Mosely, who took it in company with normal pupae in the River Test, Hants., ix.1920 (see fig. 6,c).

Blood-sucking.—Ample confirmation has been obtained of the statement that this species normally feeds in horses' ears, and it would seem that it is the only blood-sucking fly in Britain which does so; its activities must therefore be only too well known to agriculturists. Numbers of females were taken from ears of barge-horses on the canal near Uxbridge, 21.viii.16, no other species being seen. On 5th April 1918 (as well as on other occasions) many were found in ears of farm horses at Letchworth, from 30 to 40 in each ear, and though all were carefully examined no other species was found. Some of these specimens were so gorged that the blood was oozing from the end of the abdomen; contrary to Pomeroy's observation regarding *S. venustum* in America, they were not at all readily disturbed. On another occasion they were found to be much more numerous still, covering the inside of the ear like velvet, with their bodies closely packed, at right angles to the surface of the ear, and holding on only by their mouth-parts and front legs. Again at Digswell, Herts., 9.vii.19, swarms of females of this species (and no other) were found flying round horses' ears; the animals were much troubled by them and endeavoured to escape by standing in the river with their heads under the arch of a bridge, against which they could flick their ears. I have never found this species biting any other part of a horse.

On one occasion (Letchworth, 19.x.17) a few specimens were found in calves' ears, while at the same time there were numerous *S. ornatum* ♀ on the bellies of the animals. I think, however, there is no doubt that the horse is the main host, as I have several times searched for them in vain in the ears of cows.

Mr. A. H. Hamm has supplied me with one or two additional records of the species biting the human subject; I have not experienced the bite myself, though a few of the insects not infrequently fly round one. It is of some interest to note that, as might be anticipated, they fly round the top of the head and often settle on a person's hat.

References.—The remarkable pupa of *S. equinum* has been described and figured by Vogler (Mitt. Schweiz. Ent. Ges. vii, p. 278, 1886), who did not however recognise the species he was describing. There are two other described pupae which bear an approximate resemblance to *S. equinum*. These are *S. botulibranchium*, Lutz, from South America and *S. damnosum*, Theo., from tropical Africa—the latter recently described by Pomeroy (Ann. Mag. Nat. Hist. (9) v, p. 80, 1920). The adult of Lutz's species is unknown; that of *S. damnosum* has a much greater resemblance

to *S. reptans* than to *S. equinum* in general characters, though in the male genitalia there is certainly some resemblance between *S. damnosum* and *S. equinum*. From these and similar facts we may conclude that pupal characters may be useful as indicating unexpected relationships, but can hardly be adopted for defining subgenera.

11. *S. latipes*, Mg. (figs. 1j, 2e, 3d, 4l).

Adult.—Rearing experiments have shown that the female I previously described as *S. latipes* was really that of *S. angustitarsis*; *S. latipes* ♀ is easily recognisable by the characters given in the key. The pink abdomen is nearly always very noticeable in life.

Larva.—General colour dirty greyish or brownish, with indefinite darker markings. Head dark, with slightly darker markings arranged in the usual cross-shaped manner, but very indistinct. Antennae extremely slender, first joint about six times as long as broad, somewhat narrowed towards the tip, second nearly twice as long but not half as broad, third half as long and half as broad as the second, fourth minute. Mentum with 11 teeth in the terminal row, the central one and the second from each end much larger than the others. On the ventral side of the last abdominal segment are two conical papillae, nearly as long as the gills but with broad bases. Anal sucker of about 80 rows, each containing 12–15 hooks. Skin round anus bare. Anal gills each with about 8 branches.

Pupa.—Respiratory filaments much longer than the pupa, four in number, arranged in two shortly but distinctly stalked pairs. All the filaments of about equal thickness, slightly and evenly tapering to the tips, and arranged in one plane (the vertical). Cocoon tough, closely-woven, about 1·5 times as long as broad, usually broader in the middle than in front, height in front barely equal to the breadth; front margin thickened and provided with a rather long median projection. There is a definite inner layer surrounding the abdomen of the pupa but not attached to the surface of the stone; no floor to anterior part of cocoon; mouth widely open.

Habitat.—Small temporary streams and rills, especially those with stony bottoms, and perhaps most frequently in or near woods; only very exceptionally in rivers or fair-sized streams. The larvae congregate mainly on the undersides of stones, or if these are not available, under dead leaves and twigs; the pupae are more usually on the upper surface, and never deeper than an inch or two.

Breeding Season.—The flies appear early in April, and there seems to be normally only one brood in the year; the rate of development of the larvae seems to be very irregular, and this will probably account for the presence of pupae as late as the middle of June. In favourable circumstances however it is not improbable that there may be a small second brood.

Egg-laying takes place in the early summer, and though I have never found the eggs, I have watched gravid females hovering over little sheltered spots of the rills and every now and then dropping suddenly almost to the surface of the water and rising again as suddenly. I could not ascertain whether eggs were being dropped, but if they were, the species has a very different method of oviposition from that of others of the genus.

Many of the streamlets in which *S. latipes* abounds are completely dry for the greater part of the summer, and though they may fill up during the autumn rains, I have not yet detected the presence of young larvae before about Christmas. It will be of considerable interest to discover exactly what happens to the insect during the dry season. I consider it most probable that it exists in the egg-stage, and that the egg-burster is a modification similar to that found in mosquitos of the *Aedes* group, which are capable of sustaining prolonged desiccation in the egg stage.

Material collected.—Larvae and pupae occurred in abundance in most of the streamlets round Harrow, Pinner, Northwood, Ruislip and Stanmore, Middlesex, in the spring of 1915 and 1916. The earliest pupae were found about the end of March. Hatch End, Middlesex, 7.viii.15, larvae and pupae in stream which had been dry from middle of May to beginning of July; larvae not nearly so common as in the spring. Streamlets in and near Knebworth Wood, Herts., half-grown larvae 4.iii.17, larvae and pupae on stones and grass, 11.iv.17, numerous under stones, 10.v.20. Norton Common, Letchworth, Herts., small larvae xii. 1916, somewhat larger ii. 1917, pupae and some larvae 17.iv.17, a few larvae left 7.vi.17; many small larvae, chiefly second stage, but a few first and third stage, 21.xii.19; the stream was quite dry from June till early November 1919; larvae of all stages i–vi, but chiefly v, 29.ii.20. Burnham Beeches, Bucks, iv.1916. River Lea, near Hatfield, Herts., v.1916, two pupae on *Ranunculus* in company with numerous *S. ornatum* and *S. equinum*; one of these had the anterior projection of the cocoon forked, perhaps owing to its unusual environment. Streamlets on flanks of Goat Fell, Isle of Arran, v.1919, up to a height of 1,000 ft. Inverleithen, near Peebles, 7.viii.1910, larvae of various sizes on grass (*Dr. J. Rettie*, per *Dr. J. H. Ashworth*). New Forest, Hants., 1.v.1920, larvae, mostly full-grown, and pupae, on grass and *Ranunculus* in small streams running into Beaulieu River, also in the Beaulieu River itself about a mile above Beaulieu. River Test, Hants. (*M. E. Moseley*). In numerous small stony streamlets in the valleys of the Dart and Teign, S. Devon; also a few in the River Teign below Fingle Bridge, vi.1920.

Variation.—There seems to be but little variation in the adult or pupa, except to a slight extent in size and in the length of the stalks of the pairs of pupal filaments and the length of the anterior projection of the cocoon. The larvae also are fairly constant in any one locality, though the head markings vary in intensity, and the young larvae have usually darker heads than the larger ones, with less defined markings. The New Forest larvae had rather distinct reddish-brown bands on the abdomen, much as in *S. aureum*; these markings are usually hardly perceptible in Hertfordshire specimens.

Blood-sucking.—For a long time I considered that this species was not a blood-sucker, and in fact it was long before I captured a female on the wing, in spite of searching for them near the places where the larvae were abundant. Swarms of males were found hovering in the shelter of hedges, but at first no females were seen. However in the Isle of Arran, at the end of May 1919, females were very numerous in Sannox Wood and by some of the wooded burns, flying round us in swarms, and so far as could be ascertained all the bites received were inflicted by this species; it could easily be recognised by the naked eye on account of the pink abdomen.

References.—The larva and pupa have been figured (rather inaccurately) by Lt.-Col. A. Alcock in *Entomology for Medical Officers*, 1911, p. 126. There is also a very good and detailed description, with figures, of the tracheal system of both larva and pupa by Taylor (*Trans. Ent. Soc. London*, 1902, p. 701). Neither of these authors however had named the species. The species in which Weismann (*Abh. Senckenberg. Natf. Ges.* iv, p. 249, 1862) studied the development of the tracheal system would also appear from his figures to be *S. latipes*, not *S. sericeum*. Friederichs (*Zeitschr. f. angew. Ent.*, vi, p. 61, 1919) sinks *latipes*, Mg., as a synonym of *maculatum*, Mg., but this seems to me to be without justification.

12. *S. angustitarsis*, Lundstr.* (figs. 1l, 4n).

Larva.—Head with eight dark spots above, four arranged in the usual cross-like formation, the other four in two transverse pairs near the posterior margin; a dark stripe over the eyes, including a small blackish dot. Antennae much as in *S. aureum*, the second and third joints a little longer. Mentum as in *S. aureum*. The other characters cannot be given, as the only two larvae which have yet been found had partly transformed to pupae. The head-markings should be unmistakable, though similar to those of *S. aureum*.

Pupa.—Respiratory filaments four in number, longer than the pupa, all arising practically from the same point, widely divergent at the base, the upper two considerably swollen basally. Cocoon as in *S. latipes*, except that the anterior projection is usually very short.

Habitat.—Weedy rivers with only a moderate current, in company with other species, such as *S. ornatum*, *S. argyreatum* and *S. equinum*, but always in much smaller numbers, and might usually be regarded as rather scarce. Very rarely in small streams.

Breeding Season.—Nothing definite can be stated except that pupae have been collected from April to July and in September, while females have been taken on the wing in November.

Material collected.—Pupae have been obtained as follows:—*Cambs.*: Stapleford, 28.iv.16, on grass; 1.vii.15, on *Sparganium*. *Herts.*: River Lea near Hatfield, v.1916; River Ivel near Radwell, 16.vi.17, on *Ranunculus*. *Suffolk*: River Lark, near Mildenhall, 30.ix.15, and 25.iv.16, on *Sparganium*. *Hants.*: River Test (*M. E. Mosely*). *Wales*: Anglesey, 19.ix.15, one pupa on stone in small stream across field (*C. B. Williams*).

Additional localities for the adults are:—Timworth, Suffolk (*Lt.-Col. Nurse*); Wicken, Cambs. (*F. W. E.*); Shefford, Beds. (*F. W. E.*); Oxford district (*A. H. Hamm*); Woolhampton, Berks. (*A. H. Hamm*). Besides these, females were wrongly recorded as *S. latipes* in my previous paper from Bovisand, Devon; Corfe Castle, Dorset; and Stockenchurch, Oxon.

Variation.—Very little noticed, but the femora and tibiae of the female vary in ground-colour; the lightest specimens show most distinctly the dark ring near the base of the hind tibiae, while in the darkest it is barely distinguishable. The hind metatarsi are always dark.

* See synonymy below, and under *S. aureum*.

Blood-sucking.—No evidence.

References and Synonymy.—The female I previously attributed to *S. latipes* really belongs here, together with some of those I included with *S. angustipes*, but the female I formerly regarded as this species is *S. aureum*. The pupa figured by Fries as that of *S. reptans* may be this species; also the pupal filaments figured by Tömösvary (Rovartani Lapok, i, p. 34, 1884) and Horvath (*loc. cit.* p. 195, pl. iii), though attributed to *S. columbaczense*, may belong to this species, as their structure seems identical. In any case the *S. columbaczense* of these writers would seem to belong to the same group as *S. angustitarsis*. Friederichs (Zeitschr. f. angew. Ent., vi, p. 61, 1919) found the species in the river Aar at Bern and figures the male hypopygium and the pupa and pupal filament; the figures have been transposed with those of *S. maculatum* (*i.e.*, *S. latipes*).

13. ***S. aureum***, Fries* (figs. 1k, 2m).³

Larva.—General colour dirty greyish or greenish grey, with rather ill-defined reddish-brown markings. Head with five or six well-defined elongate dark marks; two transverse on the posterior margin, three or four longitudinal in the form of a cross, the middle one linear and sometimes divided (making six in all); all these sometimes enclosed in a dark cloud; a dark stripe over the eyes, including a distinct blackish dot. Antennae with the first joint rather swollen, except on its apical fourth, which is rather suddenly narrowed, second joint much more slender but not greatly longer than the first, third half as long as the second, fourth minute. Mentum with 11 sharply pointed teeth in the terminal row, the central one and the second from each end much larger than the others. Two conical papillae on the ventral side of the last abdominal segment. About 70 rows in the anal sucker, each with 12–15 hooks. Skin round anus bare. Gills simple.

Pupa.—Respiratory filaments much longer than the pupa, four in number, all arising almost at the same point, but all practically in the same plane; all equally though very slightly thickened towards the base. Cocoon constructed as in *S. latipes*, but without any trace of a median anterior projection.

Habitat.—Small temporary streams, especially when stony; sometimes also found in rivers, but not in great numbers.

Breeding Season.—My observations are somewhat contradictory and unsatisfactory, but there would appear to be at least two broods in the year, of which that appearing in the early autumn is much the most numerous in individuals. The only definite evidence available as to over-wintering is that Mr. A. H. Hamm took a female in the Oxford Museum, 3.ii.1916.

I found eggs, laid almost certainly by this species, in August 1915, in patches on blades of grass at the surface of the water, and on stones below the water. The eggs are dark brown and hard-shelled, not enclosed in jelly; some which I kept under a dripping tap hatched at the end of a week and the issuing larvae had well-developed egg-bursters, resembling those of *S. latipes*.

Material collected.—Larvae and pupae have been collected as follows:—*Middlesex*: in all the small streams round Harrow, Pinner and Northwood, viii. 1915; most of

* See synonymy below.

these streams had contained *S. latipes* in the spring, but in August only *S. aureum* with (in one case) a few *S. latipes* and an occasional *S. ornatum* could be found ;* in the spring of 1916 *S. latipes* was again abundant, and one or two *S. aureum* were found with it. Harefield, 19.ix.15, one pupa in small weedy stream with many *S. ornatum*. Bucks. : stony stream at Burnham Beeches, 10.ix.15. Devonshire : one pupa in a small stream at Start Point ; one larva in the river Otter at Tipton St. John, vi.1920 ; one or two larvae and pupae in the river Sid at Sidmouth, vi.1920. Hants. : Botley, New Forest, iii. 1915, among water-weeds (*Lady Jenkyns*) ; River Test (*M. E. Mosely*). Cambs. : Cambridge Botanic Gardens, 1.x.15 ; larvae and pupae in large numbers on roots of a tree in small stream 10 inches wide by 1 inch deep ; all these had disappeared by Christmas 1915, and at Easter 1916 there were no signs of larvae ; very young larvae were present in June 1916. Suffolk : Barton Mills, 30.ix.15, a few pupae in a backwater of R. Lark ; R. Lark near Mildenhall, 25.iv.16, a few pupae with *S. ornatum*, etc., on water-plants. Lancashire : Manchester district (*H. Garnett*). Scotland : small rills on flanks of Goat Fell, Isle of Arran, v. 1919 ; a few pupae among more numerous *S. latipes*. Additional records for the adults are :—Oxford district (*A. H. Hamm*) ; Porthcawl, Glamorgan (*Lt.-Col. Yerbury*). Blyth and Bulwell Hall, Notts. (*J. W. Carr*). Snailbeach, Salop (*F. W. E.*). Possibly a few of the records given previously for *S. latipes* really apply to this species, but both are common and widely distributed.

Variation.—The central mark (or when it is divided, the two central marks) on the head of the larva varies somewhat in shape ; the respiratory filaments of the pupa have sometimes a barely distinguishable stalk to each pair. The stilus of the male adminiculum varies slightly in width and the claspers in shape ; also the amount of hair on the basal pieces of the male genitalia is not constant. The male legs are usually almost entirely dark, but often the basal two-thirds of the femora and tibiae are perceptibly paler, this appearance being heightened by the golden pubescence. There is a variable amount of yellow on the hind metatarsus of the female.

Blood-sucking.—No evidence. I have failed to induce captive females to bite by confining them over my hand, but this is also true of other species.

References and Synonymy.—Rearing experiments have shown that the male and female which I previously described as *S. aureum*, Fries, really belonged to different species ; I now propose to interpret Fries' name as applying to the female described in Bull. Ent. Res. vi, p. 39, noting meanwhile that in that description I had overlooked the fact that the hind metatarsi are usually to a large extent yellow. The male I previously took for *S. aureum* therefore becomes *S. angustitarsis*, Lundstr. ; the male of *S. aureum* is really my *S. angustipes* (Bull. Ent. Res. vi, p. 40) ; this latter name therefore falls as a synonym of *S. aureum*, Fries. Most of the females assumed to be *S. angustipes* do not belong here but are really *S. angustitarsis*.

S. aureum also occurs in North America under the name *S. bracteatum*, Coq. I have examined a male from Spartanburg, S.C., 14.viii.13 (*A. W. J. Pomeroy*) and cannot find any appreciable difference either in the genitalia or in any other character. The larvae and pupae of *S. bracteatum* as described by Strickland (Jl. Morph.xxiv,

* I was at first inclined to regard this as indicating that *S. aureum* was the autumn form of *S. latipes* ; but there are good structural differences between the two species in all their stages.

p. 45, pl. i, 1913) and Pomeroy (U.S. Dept. Agric. Bull. 329, p. 13) also agree almost entirely in structure, coloration and habits with British *S. aureum*, the only difference being in the shape of the larval antennae, which may depend on the preparation.

The pupa has also been figured by Garnett (Trans. Manchester Microsc. Soc. 1914 [1916], p. 10, pl. i) as that of *S. reptans*. The adults described by Corti (Atti Soc. Ital. Sci. Nat. liii, p. 192, 1914, and liv, p. 223, 1916) as *S. aureum* apparently agree with the present interpretation of Fries' species, which is evidently widely distributed in Europe. Dr. G. Enderlein has sent me specimens from the neighbourhood of Berlin; he also had determined them as *S. aureum*. There is an African representative with a wide distribution in that continent, which has recently been described by Pomeroy as *S. aureosimile*.

14. ***S. subexcisum***, Edw. (figs. 1*m*, 2*f*, 3*e*, 4*o*).

Larva.—General colour pale dingy yellowish-brown. Head pale yellowish, clypeus with sharply defined black marks; the largest and most conspicuous a wedge-shaped one in the middle near the posterior margin; a small one anterior to this; a pair of small ones rather close together one on each side of the anterior end of the wedge-shaped one; also a transverse black mark at each posterior angle; a conspicuous dark stripe over the eyes, including a small blackish dot. Antennae blackish, very long, 9-jointed, first joint slightly swollen towards the base, about six times as long as broad, followed by four short joints, each a little longer than broad; sixth and seventh rather longer, twice as long as broad; eighth joint very long and slender, as long as the first; ninth minute. Mentum with 9 teeth in the terminal row, the middle one and the two at each end larger than the remaining four; sides of mentum with one or two long hairs. A pair of well-developed ventral papillae on the last abdominal segment. Anal sucker with about 80 rows, each with about 10–12 hooks. Skin round anus bare. Gills simple.

Pupa.—Respiratory filaments long, six in number; the first division is close to the base, into short stems diverging almost at two right angles; the upper stem divides into two branches, which continue in a vertical direction as far as the height of the pupa, then bend forwards along the anterior projection of the cocoon; the lower stem is shorter than the upper, dividing almost immediately into two branches, each of which is forked at some distance from its base. Cocoon as in *S. latipes* with a long anterior projection.

Habitat.—Stones and grass-blades in small temporary streams in or near woods, in company with *S. latipes*, but always comparatively scarce.

Breeding Season.—The few specimens reared were obtained in the late spring. As in the case of *S. latipes*, there cannot normally be more than one brood in the year.

Material collected.—Two males were reared from pupae found on stones in a small rill on Stanmore Common, Middlesex, iv.1916. A single female was reared from a pupa found on a stone in a small stream at Knebworth Wood, Herts., 10.v.1920, and half a dozen larvae were found at the same time and place on stones and grass-blades. In each case the specimens were associated with large numbers of *S. latipes*.

A small number of females were taken at Glen Sannox and Glen Catacol, Arran, v.1919, flying in company with *S. latipes*; also at Gidleigh Park, S. Devon, 2.vi.1920.

Variation.—The pupal filaments dissected from one larva showed a small stump near the tip of one of the vertical branches, or both sides. The smaller dark spots on the larval head vary in size and distinctness.

15. *S. yerburyi*, sp. n. (fig. 4*p*).

Adult female.—Differs from that of *S. subexcisum*, Edw., only in the colour of the vestiture of the mesonotum: instead of being all yellowish, there are three stripes of dark brown, the middle one divided by a line of pale scales or hairs; the middle stripe is longer than the side stripes, but does not nearly reach the front margin.

Pupa.—Differs from that of *S. subexcisum* as follows:—Vertical stem of upper respiratory filaments shorter, forking near the base, each branch forking a second time at no great distance from the first fork, so that there are eight branches in all.

Material collected.—A single female (the type of the species) was reared from a pupa collected at Knebworth Wood, Herts., 10.v.20, in company with many *S. latipes* and one *S. subexcisum*. There are three other females in the British Museum Collection, from Nethy Bridge, 18.vi.05, and Nairn, 28.v.05. (*Lt.-Col. Yerbury*). These were referred to in my previous paper as a variety of *S. subexcisum*, but since the difference in the female proves to be correlated with a difference in the pupa, it is perhaps preferable to regard the two forms provisionally as distinct species. The male and larva are unknown to me. The discovery of the former may possibly prove the species to be identical with one of those described by Lundström.

16. *S. hirtipes*, Fries (figs. 2*g*, 3*f*, 7).

I have not met with the early stages of this species, and they do not appear to have been described by any European author. Since however the American form described under this name appears to be identical in the adult, the following characters given by Johannsen and Malloch for American specimens will probably hold good for the British race also.

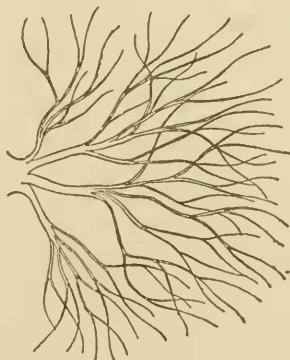


Fig. 7. *Simulium hirtipes*, Fries; side view of respiratory organ of pupa (from Malloch).

Larva.—Colour of upper surface yellowish on the thorax, fuscous on the abdomen. Head rich brown, posterior margin nearly black. Antennae 3-jointed,* first joint occupying two-thirds of the length. Mentum with 7 teeth in the terminal row,

* This may possibly have been an error of observation on the part of the American writers. The division between the first two joints is always rather indistinct.

all but the outer ones strongly trifid. About 100 rows of hooks in the anal sucker, 12 in a row. Gills simple.

Pupa.—Respiratory tufts much shorter than the pupa, divided near the base into four main branches, the two inner ones larger than the outer ones, each branch again dividing two or three times into twigs, so that upwards of 60 filaments may be counted. Cocoon, a dark matted mass of silk, of no definite form, secreted on the rock, the pupae only partly covered.

Distribution.—Mr. F. Jenkinson has shown me a specimen said to have been taken at Crowborough, Sussex. Otherwise I have no records to add to those previously given, which all referred to the Scottish highlands.

17. ***S. tredecimatum***, sp. nov. (figs. 2*h*, 4*q*).

Adult.—Not yet recognised.

Larva.—One of the largest, if not the largest, of the genus. Head markings of the same type as in *S. ornatum*, but more diffused; a dark dot in the region of the eyes, and a pair about the middle of the clypeus. Antennae 4-jointed, the first two joints membranous, pale, the last two dark; first and third joints about equal in length, second more than twice as long as either, fourth minute. Mentum with 11 divisions apically; except for the middle three these are so short and blunt that they can hardly be called teeth; the divisions are not noticeably trilobed. Sides of mentum with about four long hairs. About 110 rows of hooks in the anal sucker, and about 18–23 hooks in each row. No ventral tubercles on last abdominal segment, but the whole segment is much more swollen ventrally than in most species. Skin round anus bare. Anal gills simple.

One specimen was sufficiently developed to allow the pupal respiratory organs to be dissected out; these agreed closely with the pupa described below.

Pupa.—Respiratory organ hardly more than a quarter as long as the pupa, divided into thirteen filaments in all. At the base there are four main divisions; the first of these extends upwards nearly vertically for a short distance, emitting two branches close together near its base and a little higher up dividing into three; the second divides into two close to its base; the third and fourth each split into three a little way from the base. No cocoon present in the material available.

The above description has been drawn up from one pupa (evidently freshly formed) and a number of larvae in the British Museum, bearing the label, "from stomach of a trout, England." Most unfortunately no other data are available, but the species is so very distinct in both larval and pupal stages that it seems worth while to describe it, in order to call attention to the existence of such a remarkable form, even though it may ultimately be discovered that there was an error of labelling, or that the adult was already known under another name. There is a bare possibility that the species may be *S. hirtipes*, the early stages of which, as mentioned above, have not been described from Europe. However it seems very unlikely that two forms which are to all appearances identical in the adult stage (as are the American and European races of *S. hirtipes*) should yet differ so widely as larvae and pupae. No species has hitherto been described from any part of the world with 13-filamented respiratory organs in the pupa.
